KEITHLEY

Model 225
Instruction Manual

Contains Operating and Servicing Information
for the Model 225 Current Source

Document Number: 29039 Rev C
Publication Date: February 1984

WARRANTY

We warrant each of our products to be free from defects in material and workmanship. Our obligation under this warranty is to repair or replace any instrument or part thereof which, within a year after shipment, proves defective upon examination. We will pay local domestic surface freight costs.

To exercise this warranty, write or call your local Keithley representative, or contact Keithley headquarters in Cleveland, Ohio. You will be given prompt assistance and shipping instructions.

REPAIRS AND CALIBRATION

Keithley Instruments maintains a complete repair and calibration service as well as a standards laboratory in Cleveland, Ohio.

A Keithley service facility at our Munich, Germany office is available for our customers throughout Europe. Service in the United Kingdom can be handled at our office in Reading. Additionally, Keithley representatives in most countries maintain service and calibration facilities.

To insure prompt repair or recalibration service, please contact your local field representative or Keithley headquarters directly before returning the instrument. Estimates for repairs, normal recalibrations and calibrations traceable to the National Bureau of Standards are available upon request.

KEITHLEY

Keithley Instruments, Inc./28775 Aurora Road/Cleveland, Ohio 44139/U.S.A./(216) 248-0400/Telex: 98-5469

WEST GERMANY: Keithley Instruments GmbH/Heiglhofstrasse 5/D-8000 München 70/(089) 714-40-65/Telex: 521 21 60

GREAT BRITAIN: Keithley Instruments, Ltd./1, Boulton Road/Reading, Berkshire RG2 ONL/(0734) 86 12 87/Telex: 847047

FRANCE: Keithley Instruments SARL/2 Bis, Rue Léon Blum/B.P. 60/91121 Palaiseau Cedex/(6) 011.51.55/Telex: 600933F

NETHERLANDS: Keithley Instruments BV/Arkelsedijk 4/NL-4206 AC Gorinchem/(01830) 25577/Telex: 24 684

SWITZERLAND: Keithley Instruments SA/Kriesbachstr. 4/CH-8600 Dübendorf/01 821 94 44/Telex: 57 536

AUSTRIA: Keithley Instruments Ges.m.b.H./Döblinger Hauptstr. 32/A-1190 Wien/0222 314 289/Telex: 13 45 00

Instruction Manual
Model 225
Current Source

©1976, Keithley Instruments, Inc.
Cleveland, Ohio, U.S.A.
Document Number 29039

CONTENTS

Section	Page
SPECIFICATIONS	1
1. GENERAL DESCRIPTION	2
2. OPERATION	4
3. CIRCUIT DESCRIPTION	8
4. ACCESSORIES	10
5. SERVICING	11
6. CALIBRATION	12
7. REPLACEABLE PARTS	19
SCHEMATIC	31

ILLUSTRATIONS

Figure No.	Title	Page
1	Front Panel.	1
2	Front Panel Controls	3
3	Rear Panel Controls.	3
4	Connections.	4
5	Resistive Load	6
6	Current Sink	6
7	Capacitive Load.	6
8	Inductive Load	6
9	Floating Supply.	6
10	Volt Limit Characteristic.	7
11	Modulation	7
12	Block Diagram.	8
13	Component Layout, PC-227 (Switch Board).	13
14	Component Layout, PC-228 (Mother Board).	13
15	Component Layout, Switch S101.	14
16	Chassis - Top View	14
17	Accuracy Check	18
18	Regulation Check	18
19	Modulation Check	18
20	Inductive Load Check	18
21	Current Mode vs Voltage Mode Waveforms	18
22	Top Cover Assembly	21
23	Bottom Cover Assembly.	21

CAUTION

IF THE DECADE CURRENT DIALS ARE SET TO 0-0-0 and if the Output Selector switch is not at STANDBY, a COMPLIANCE VOLTAGE up to 100 volts may be present at the output terminals. For maximum operator safety the Model 225 Current Source should always be set to STANDBY mode when no current output is needed. The Output Selector switch (S105) should also be set to STANDBY prior to changing current dial settings and/or Voltage Compliance. This will ensure that no transient currents will be generated.

WARNING

This instrument is not approved for use in "hazardous locations" as defined in the National Electrical Code, Classes I, II, and III.

Class I: Those locations in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures.

Class II: Those locations that are hazardous because of the presence of combustible dust.

Class III: Those locations that are hazardous because of the presence of easily ignitable fibers or flyings.

SPECIFICATIONS

OUTPUT:

D.C. Current: 10^{-7} ampere full range to 10^{-1} ampere in seven decade ranges, 3-digit in-line readout.

Voltage: 100 volts maximum. Compliance limit continuously variable from 10 to 100 volts.

Polarity: Positive or negative.

Floating: ±500 volts maximum off chassis ground, less than 5 ppm of full range change in output current per volt.

RESOLUTION: Three significant figures from 10^{-7} to 10^{-1} ampere. "Trim" potentiometer permits 0.02% of full range or better resolution.

ACCURACY: ±0.5% of reading, ±0.05% of full range.

STABILITY: ±0.02% of reading, ±0.005% of full range on the 10^{-1} to 10^{-6} ampere range, (±0.1% of reading ±0.02% of range on the 10^{-7} ampere range) the first hour or in subsequent 8-hour periods after a 1-hour warm-up and at reasonably constant ambient temperature.

NOISE: Less than 0.01% rms of full range above 5 Hz.

LOAD REGULATION: ±0.005% of full range from no load to full load on the 10^{-1} to 10^{-6} ampere range, ±0.05% on the 10^{-7} ampere range (with FILTER "OFF").

LINE REGULATION: ±0.005% of full range for 10% change in line voltage.

OVERLOAD PROTECTION: Voltage limited to compliance voltage setting of polarity selected. Automatic recovery from overload.

MODULATION: Transformer input permits modulation of current from 50 Hz to 500 Hz. Input Z approximately 500 ohms.

FILTER: For operation with inductive loads up to 100 millihenries having greater than 10^{-6} L/R ratio. Limits shunt output impedance to 1 microfarad shunted by greater than 10^{10} ohms.

ENVIRONMENT: 50% relative humidity limit at 25°C.

CONNECTORS: Output (front and rear panels): BNC

POWER: 105-125, 210-250 volts (switch selected), 50-60 Hz; 25 watts.

DIMENSIONS, WEIGHT: 5½" high x 8¾" wide x 10" deep; net weight, 8 pounds.

SECTION 1. GENERAL DESCRIPTION

1-1. GENERAL. The Model 225 is a current source with full scale ranges from 10^{-7} to 10^{-1} ampere.

1-2. FEATURES.

a. Resolution. The three decade dials plus a "Trim" potentiometer provides a resolution of .02% of full range.

b. Compliance Voltage. A front panel Compliance Control provides an adjustable maximum compliance voltage from 10 to 100 volts.

c. Accuracy. The three decade dials adjust the output current to ±.05% of full range and ±.5% of reading.

d. Polarity. The OUTPUT SELECTOR Switch provides polarity selection without changing connections to the load.

e. Floating Capability. The instrument LOW can be floated up to ±500 volts above chassis.

f. Modulation. The output current can be modulated over a frequency range from 50 to 500 Hz.

TABLE 1-1.
Front Panel Controls

Control	Functional Description	Paragraph
Power Switch (S202)	Controls line power to instrument. Decimal point serves as a pilot lamp.	2-4, a
OUTPUT SELECTOR Switch (S105)	Selects positive or negative polarity or standby position.	2-4, b
VOLTAGE COMPLIANCE Control (R117)	Sets the maximum compliance voltage which can be developed at the OUT terminal.	2-4, c
LIMIT Indicator (DS101)	When lighted, the instrument is in Voltage mode.	2-2, e
Range Switch (S101)	Selects the full scale range. The decimal point is automatically positioned by the Range switch.	2-4, d
Selector Switches (S102, S103, S104)	Selects the magnitude of current in 3 decade positions.	2-4, e
FINE Control (R138)	Adjusts current.	2-4, f
FILTER Switch (S106)	When set to "ON", the switch connects a 1 μF capacitor at the OUT terminal.	2-4, g

TABLE 1-2.
Rear Panel Controls and Terminals

Control or Terminal	Functional Description	Paragraph
Power Cord (P201)	Provides line power to instrument.	-
LINE VOLTAGE Switch (S201)	Sets instrument for 117 or 234 V line operation.	-
FUSE (F201)	Type 3AG, Slow Blow. 117 V: 1/4A; 234 V: 1/8A	2-1, a
OUT Receptacle (J104)	Output high connection.	2-1, a
LOW Terminal (J201)	Output low connection.	2-1, a
GROUND Terminal (J20)	Ground (chassis) connection.	2-1, a
MODULATE Receptacle (J101)	Connection to modulation transformer.	2-1, b
Shorting Link	Provides connection between LOW and GROUND.	-

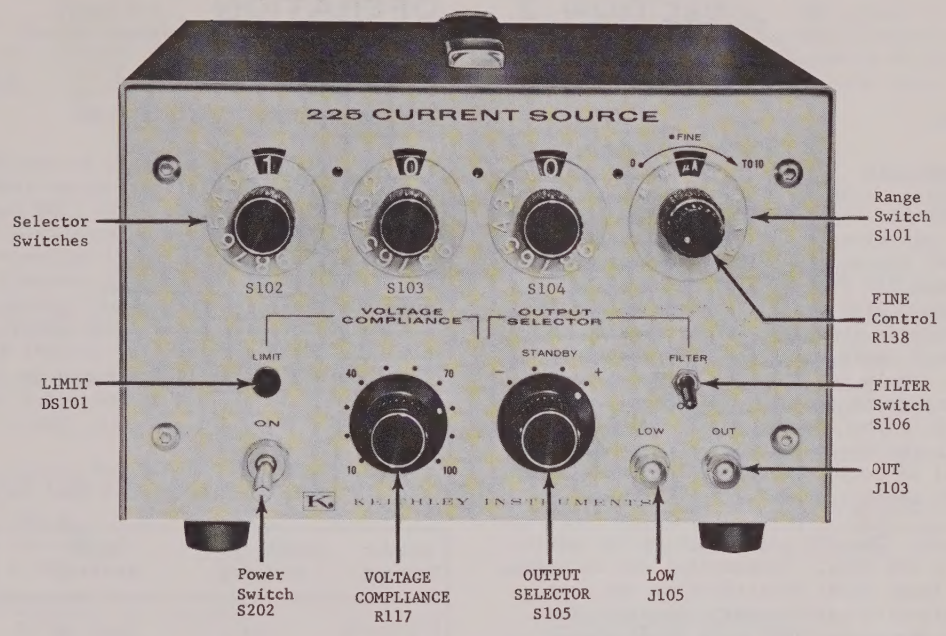


FIGURE 2. Front Panel Controls.

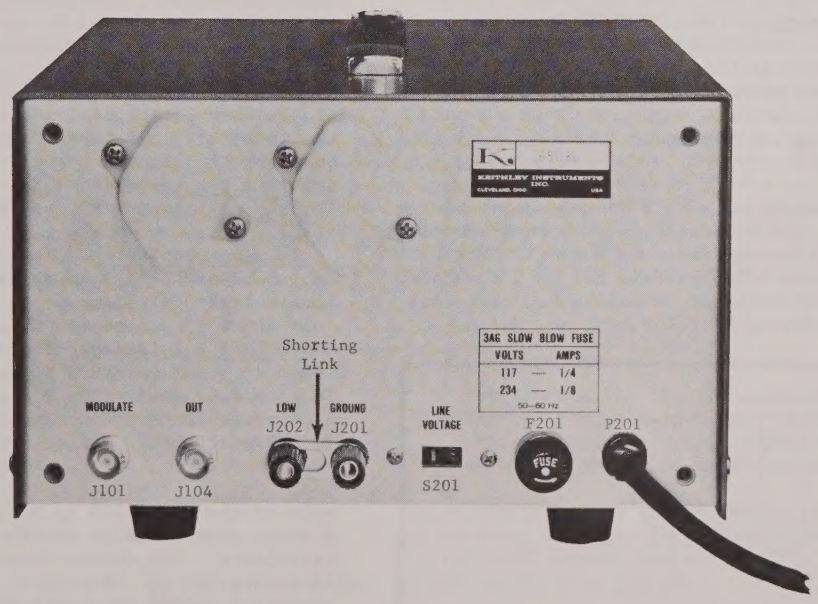


FIGURE 3. Rear Panel Controls.

SECTION 2. OPERATION

2-1. CONNECTIONS.

a. Output Connectors.

1. Front Panel. The connectors on the front panel are BNC type receptacles (Keithley part no. CS-15). The OUT receptacle (J103) provides connection to the Model 225 Output High. (The center terminal is Output High while the outer shield is connected to chassis ground.) Connections to the output load can be made using the OUT receptacle when the Model 225 is not floating. (For a more complete discussion of floating operation, refer to paragraph 2-2 f.) The LOW receptacle (J105) provides a connection to the Model 225 Output Low. (The center terminal is Output Low while the outer shield is connected to chassis ground.)

2. Rear Panel. The OUT receptacle on the rear panel is also a BNC type. Connections can be made to either the front panel receptacle or the rear panel receptacle with satisfactory results. The rear panel LOW terminal (J104) is a binding post (Keithley part no. BP-11G) which is connected to the center terminal of J105 (on the front panel). The rear panel GROUND terminal (J201) is a binding post (Keithley part no. BP-11B) which is connected to chassis ground. The shorting link (supplied) permits LOW to chassis ground connections.

b. Modulate Connector. The MODULATE receptacle (J101) is a BNC type connector (Keithley part no. CS-15). This connector can be used for modulating the output current using an ac modulation signal. The center terminal is connected to a transformer-coupled modulation circuit while the outer shield is connected to chassis ground.

c. Cables. Connections should be made using coaxial cables which are low-noise types with graphite coating between dielectric and shield braid. For custom length cables, Keithley Part No. SC-9 Low Noise Coaxial Cable should be used. A mating BNC connector is available by ordering Keithley part no. CS-44.

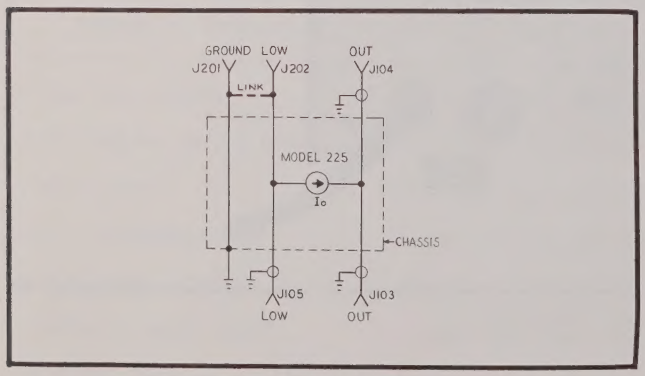


FIGURE 4. Connections.

2-2. MEASUREMENT CONSIDERATIONS.

a. Accuracy. The accuracy is specified in terms of the front panel dial setting or reading as well as the full range selected. (The FINE current control must be set to "0" position to obtain the stated accuracies.) Since the total accuracy of the Model 225 is the sum of the reading accuracy and the full range accuracy, the user should select the lowest full range for best possible accuracy. Table 2-1. shows the total accuracy for typical dial settings. (The accuracy on the 1000nA range is ±.05% of 1000 or 0.5nA plus ±.5% of 1000 or 5nA for a total of 5.5nA.)

TABLE 2-1.
Accuracy For Typical Dial Settings

Output Current	Decade Dial Setting	RANGE Setting	Total Accuracy (FINE Control set to "0")
1×10^{-6}A	0-0-1	1000 μA	± .505 μA
1×10^{-6}A	0-1-0	100 μA	± .055 μA
1×10^{-6}A	1-0-0	10 μA	± .010 μA
1×10^{-6}A	10-0-0	1000 nA	± .0055 μA

CAUTION

When the OUTPUT SELECTOR is set to + or - and VOLTAGE COMPLIANCE is set to 100, up to 100 volts will be present at the output terminals.

b. Stability. The stability is specified in terms of the front panel dial setting or reading as well as the full range selected. Since the total stability specification is the sum of the reading stability and the full range stability, the user should select the lowest full range for best possible stability.

c. Line Regulation. The line regulation is stated as ±.005% of full range for a corresponding 10% change in line voltage.

d. Load Regulation. The load regulation is specified as ±.005% of full range for a change from no load to full load. The no load to full load variation corresponds to an output compliance voltage change from 0 volts to 100 volts.

e. Output Impedance. The effective output impedance of the Model 225 is a function of the load regulation specification and the high to low insulation resistance. The output impedance for each Range setting is given in Table 2-2. The insulation resistance is 2×10^{12} ohms with the FILTER Switch OFF, but is 1×10^{10} ohms with the FILTER Switch ON. Therefore the maximum output impedance is 2×10^{12} on 100 nA and 1000nA ranges with the FILTER Switch OFF. The effective output impedance R_o can be determined by the following equations.

TABLE 2-2.
Output Impedance

Range Setting	Output Impedance*
100 mA	$2 \times 10^7\ \Omega$
10 mA	$2 \times 10^8\ \Omega$
1000 µA	$2 \times 10^9\ \Omega$
100 µA	$2 \times 10^{10}\ \Omega$
10 µA	$2 \times 10^{11}\ \Omega$
1000 nA	$2 \times 10^{12}\ \Omega$
100 nA	$2 \times 10^{12}\ \Omega$

*With Filter switch set to off.

For the 100 mA range,

$$R_L = 10^3\Omega \text{ and } \% \text{ regulation} = 0.005\%$$

$$\text{Since } \% \text{ regulation} = 100 \times \left(\frac{R_L}{R_o + R_L}\right)$$

$$\text{Then } R_o \doteq \left(\frac{100\ R_L}{\%\ REG}\right)$$

$$\text{or } R_o \doteq \frac{100 \times 1000}{0.005} = 2 \times 10^7\Omega.$$

The Model 225 will deliver the dialed current for a load resistance from 0 ohms to R_{MAX}. The value of R_{MAX} is determined by the dialed current I and the compliance voltage setting V_C where $R_{MAX} = V_C/I$. If the load resistance exceeds R_{MAX} then the Model 225 will automatically switch into Voltage Limit mode indicated by the LIMIT lamp (DS101).

f. Floating Operation. The instrument can be floated up to ±500 volts off chassis ground with less than 5 ppm of full range change in output current per volt off ground. For floating operation, the shorting link on the rear panel must be removed. In this case, two coaxial cables should be used to connect to output high and low. The outer shell of the front panel OUT and LOW receptacles are always at chassis ground for safety when floating the instrument. A filter capacitor C217 (.05 µF) is connected between the LOW and GROUND binding posts to minimize line frequency pickup. The LOW to GROUND isolation is approximately 10^7 ohms. A typical example of floating operation is shown in Figure 9. In this example, the Model 225 can be used with a voltage supply such as Keithley Model 240A to extend the maximum compliance voltage to +600 volts. The Model 225 can be adjusted for a compliance voltage of +500 ±100 volts dc. The maximum current is 10 milliamperes (for the Model 240A).

2-3. PRELIMINARY PROCEDURES.

a. Power. Check the 117-234V Switch for proper line-voltage setting. Check the fuse for proper rating. Set the Power Switch to off before connecting the power cord.

b. Connections. The output load should be connected as described in paragraph 2-1.

c. Control Settings. The output current is selected by three decade switches and a seven position Range Switch. Refer to the discussion of the front panel controls in paragraph 2-4 before power is turned on.

2-4. FRONT PANEL CONTROLS.

a. Power Switch (S202). This switch controls the line-power to the instrument.

b. OUTPUT SELECTOR Switch (S105). This switch has four positions designated "-", "STANDBY", "STANDBY", and "+". The + and - positions set the output current polarity. The two "STANDBY" positions divert the output current as shown in Figure 5. The output load is not disconnected at any position of the switch. (The shunting effect should be considered, since a small voltage can be developed across the 10-milliohm shunt and therefore across the output terminal.)

c. VOLTAGE COMPLIANCE Control (R117). This control is a continuously variable potentiometer which can be set for a compliance voltage from 10 volts to 100 volts.

d. Range Switch (S101). This switch selects the full scale range from 10^{-7} ampere to 10^{-1} ampere. The dial is designated in terms of engineering units; that is, nA, µA, and mA. The full range is determined by the position of the lighted decimal point and the designated engineering unit.

e. Selector Switches (S102, S103, S104). These switches select the magnitude of the output current in three decades. The position of the dials determines the significant digits from 0-0-0 to 9-9-9.

f. FINE Control (R138). This control is the inner dial of a dual concentric control. The fully clockwise position "10" represents 1 digit added to the right-hand dial (S104). The fully counter clockwise position is the "0" or off position. When the FINE Control is set to "0", the output current is determined only by the calibrated dials within rated specification. This control can be used to "trim" the output current to within ±.02% of full range, although the trim dial is adjustable to within ±.005% of full range.

NOTE

For example, if the three decade dials were set for 9-9-9 on the 1000 µA range, then the FINE control could be set to 150° clockwise to obtain a current output of approximately 999.5 µA.

Since the stability specification is ±.02% (or better) of reading, the useable resolution would be ±.2 µA. If the FINE control was set to "0", then the output would be 999.0 µA ±.5 µA.

g. FILTER Switch (S106). This switch should be used whenever the Model 225 must deliver current to an inductive load.

2-5. OPERATING CHARACTERISTICS. The Model 225 Current Source has a bipolar output, a constant current up to the maximum compliance setting, and automatic cross-over to constant voltage mode.

a. Bipolar Output. The Model 225 can deliver or accept current and as such it has a bipolar output.

1. Current Source. The instrument can be used as a current source with a resistive load as shown in Figure 5. In this case, the Model 225 delivers a current set by the front panel controls. The voltage developed across the load resistance R_L is $V_L = I_O \times R_L$.

2. Current Sink. The instrument can be used as a current sink as shown in Figure 6. In this case, the polarity of the current is such that current is flowing into the Model 225. The output voltage $V_O = E - I_O R_L$, where I_O is selected by the front panel dials, E is the external voltage source, and R_L is the load resistance.

b. Constant Current Mode. The Model 225 will deliver the dialed current for resistive, capacitive, and inductive loads unless the voltage required at the output terminals exceeds the compliance voltage.

1. Resistive Load. The instrument can be used to deliver current to a resistive load from 0 ohms to R_{MAX} where $R_{MAX} = V_C/I_O$ and V_C is the compliance voltage setting.

2. Capacitive Load. The instrument can also be used to charge a capacitive load as shown in Figure 7. The capacitor will be charged to the compliance voltage set on the front panel.

3. Inductive Load. The instrument can be used to deliver current to an inductive load. When the ratio of load inductance L to load resistance R is greater than 10^{-6}, the FILTER Switch must be set to "ON" for stability. The FILTER Switch connects a 1 μF capacitor across the output as shown in Figure 8.

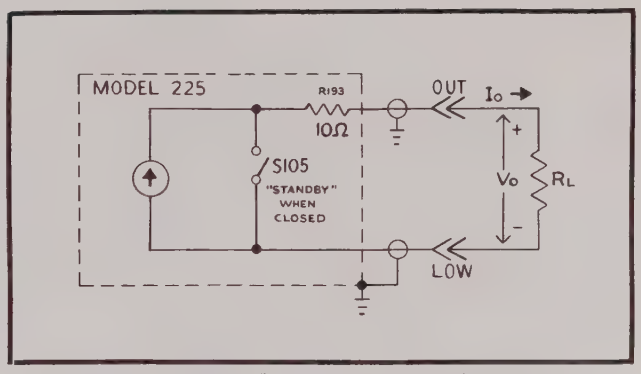


FIGURE 5. Resistive Load.

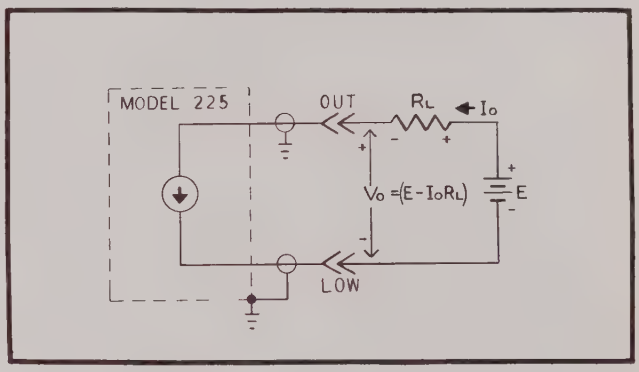


FIGURE 6. Current Sink.

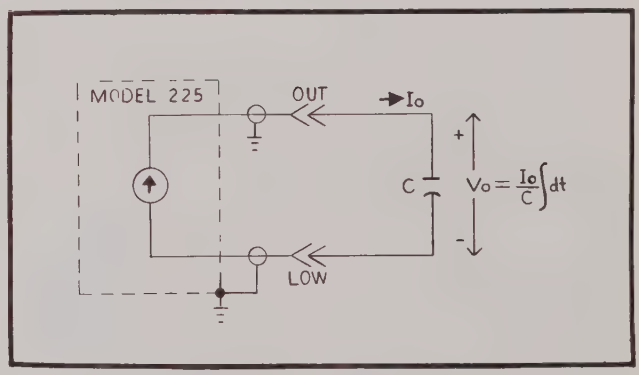


FIGURE 7. Capacitive Load.

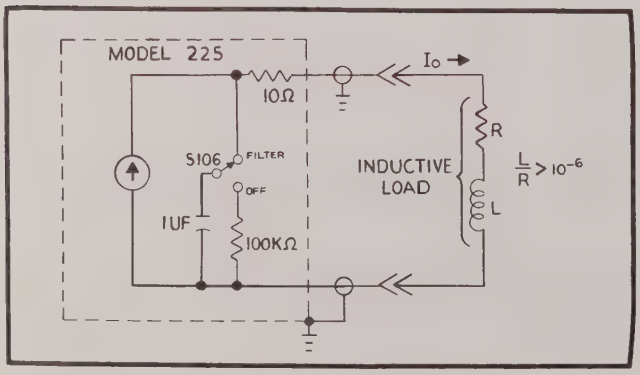


FIGURE 8. Inductive Load.

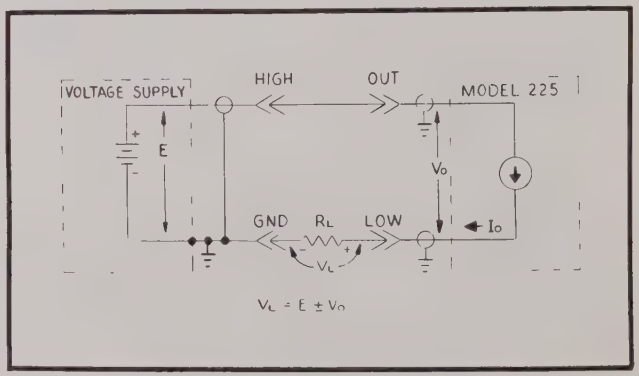


FIGURE 9. Floating Supply.

c. Constant Voltage Mode. The Model 225 can be adjusted for a compliance voltage from 10 to 100 volts. The voltage limiting will occur if the load resistance is such that $I_O R_L = V_C$. The instrument will automatically switch into a constant voltage mode (the LIMIT lamp will be lighted) such that the output voltage will not exceed the compliance setting. If the Model 225 is used as a current sink, an output voltage of 130 volts could be developed regardless of the compliance setting. The voltage limiting characteristic can be shown as in Figure 10.

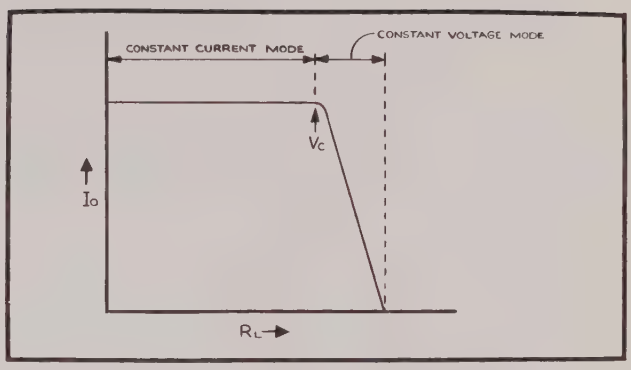


FIGURE 10. Volt Limit Characteristic

2-6. MODULATION. For convenience in making dynamic measurements, the Model 225 has a MODULATE input (J101) so that the current can be modulated in the 50 to 500 Hz range.

a. Circuitry. The Model 225 uses a transformer coupled input with 500 ohms impedance.

b. Characteristics. The peak-to-peak modulation can be adjusted up to a maximum of 40% of full range from 50 to 100 Hz decreasing to about 8% of full range at 500 Hz (with a 10 volt rms sine wave input). The modulation circuit is not calibrated so that the user must check with a known load resistance. Within a selected range the modulation is independent of decade dial setting. The capacitance of the output cables can affect the modulated current signal so that the modulation calibration should take into account this capacitance.

c. Voltage Compliance. The setting of the voltage compliance can cause clipping of the modulated current as shown in Figure 11.

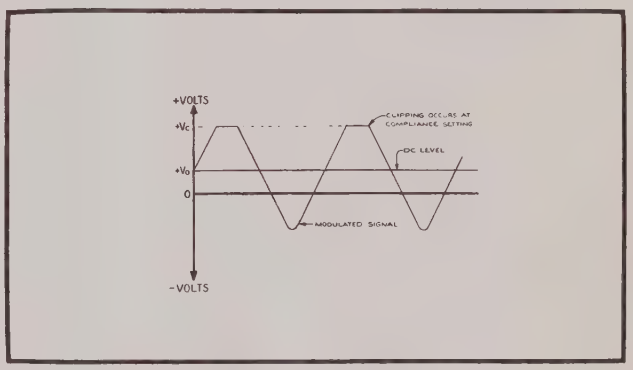


FIGURE 11. Modulation.

NOTE

When the 225 output is modulated the average value or dc level is determined by the dial settings. The output is essentially a sine-wave at the input drive frequency. The peak-to-peak modulation amplitude depends on both the magnitude and frequency of the drive signal so that the exact modulation waveform will have to be checked with an actual output load connected. Clipping of the output signal may occur depending on the compliance voltage setting. The modulation feature is especially useful when making dynamic impedance measurements on semiconductor devices, etc.

SECTION 3. CIRCUIT DESCRIPTION

3-1. GENERAL. The Model 225 is an all solid-state current source which is composed of various circuits as shown in Figure 12. These circuits include the following types.

a. High Gain Operational Amplifier "A3".
b. Differential Voltage Sensing Amplifier "A1".
c. Kelvin Divider with Precision 1-volt Reference.
d. Voltage Compliance Amplifier "A2".
e. Compliance Voltage Control.
f. Compliance Voltage Suppies ±130 V.
g. Series Regulators.
h. Range Resistor Controls.
i. Power Supplies.
j. Modulation Circuit.

3-2. THEORY OF OPERATION. The Model 225 can deliver currents from 10^{-7} to 10^{-1} amperes with a compliance voltage up to 100 volts. The current source utilizes a high gain differential amplifier "A3" which controls the current through the range resistor "R". The differential voltage sensing amplifier "A1" senses the "OUT" voltage with respect to a voltage reference. A kelvin-varley divider network permits adjustment of current in decade steps. The voltage compliance amplifier "A2" senses the voltage at a point ahead of the range resistor with respect to the compliance voltage control potential. The compliance voltage supplies allow a ±100 volt compliance at the output. These supplies deliver power to the load up to a maximum of 10 watts (100 V x 0.1 A). The series regulators are driven by the high gain differential amplifier "A3". The range resistor is selected by the RANGE Switch for currents of 10^{-7} to 10^{-1} ampere full range. The remaining power supplies are used to bias the operational amplifiers and reference zener.

3-3. CIRCUITRY.

a. High Gain Operational Amplifier "A3". This amplifier is composed of matched emitter followers (Q111 and Q114), a differential rpn gain stage (transistors Q112 and Q113), a differential npn gain stage (transistors Q109 and Q110), an emitter follower transistor Q115 and a second npn gain stage (Q116 and Q117).

b. Differential Voltage Sensing Amplifier "A1". This amplifier is composed of a matched pair of FET'S (transistors Q118A and Q118B). These devices have a low temperature coefficient (5 ppm/°C) and low typical offset-current (less than 10 pA). The offset-current however, doubles every 10°C approximately. Potentiometer R144 provides zero adjustment for the differential pair.

c. Kelvin-Varley Divider with Precision 1-Volt Reference.

1. 1-Volt Reference. The voltage reference utilizes a 9-volt zener diode (D116). (The zener is stable to 20 ppm). An accurate divider, composed of R181 and R183, divides the 9 volts down to 1-volt. Potentiometer R182 is used to adjust the reference voltage to precisely 1-volt.

2. Kelvin-Varley Divider. This divider is composed of three decade dials and a potentiometer fine control. The Selector Switches S102, S103, and S104 and FINE Control R138 permit adjustment of the voltage drop across the Range resistor R. The divider resistors are designated R148 through R180. (These resistors have 0.1% accuracy and a temperature coefficient of 25 ppm/°C.)

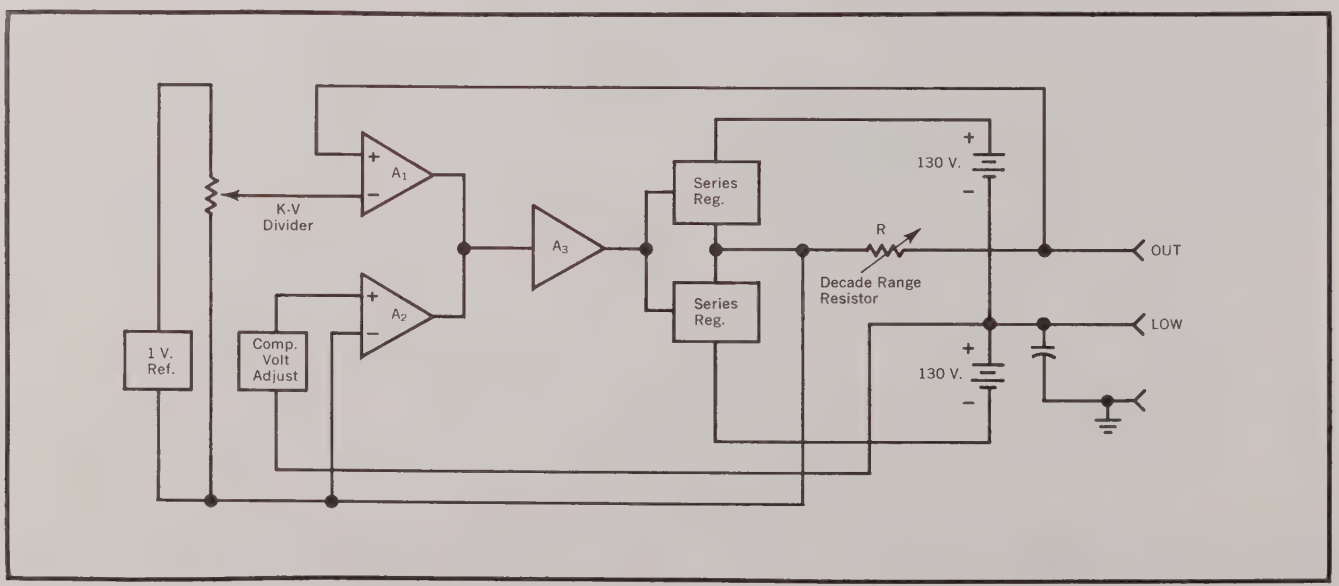


FIGURE 12. Block Diagram.

d. Voltage Compliance Amplifier "A2". This amplifier is composed of a differential gain stage; transistors Q107 and Q108. The front panel compliance control R117 sets the maximum compliance voltage desires up to ±100 volts. The bias reference for transistor Q108 is provided by a divider string composed of resistors R115, R116, R117, and R118. Potentiometer R116 provides an internal compliance voltage adjustment. The amplifier is biased "off" in the constant-current mode of operation. When the voltage at the "series regulator output" reaches the preselected compliance limit, the amplifier "A2" is turned "ON" and the Model 225 automatically changes to a voltage limit mode. The LIMIT indicator DS101 is turned on automatically when in the "voltage limit mode". For positive polarity, transistor Q108 turns on in the voltage limit mode while Q107 is turned off. The difference voltage is buffered by emitter-follower stage, Q201 and Q204. Transistor Q202 is turned on and therefore drives transistor Q207. (The LIMIT indicator is connected in series with Q207.) Transistor Q202 provides voltage level translation. For negative polarity, the difference voltage between Q107 and Q108 is such that transistors Q205 and Q206 are driven. (Transistors Q201 and Q204 act as buffer stages.) Transistor Q206 provides voltage level translation and drives Q208. The LIMIT indicator is connected in series with Q208 and is turned on. Potentiometers R203 and R207 provide control of the LIMIT indicator turn-on for + limit and - limit respectively.

e. Compliance Voltage Control. This control adjusts the maximum compliance voltage from +10 volts to ±100 volts. This is accomplished by using a linear 50 kilohm potentiometer designated R117. A constant current is driven through the resistor divider. The polarity is controlled by the OUTPUT SELECTOR Switch S105.

f. Compliance Voltage Supplies. These voltage supplies provide unregulated ±130 volts for the series regulators. AC power is obtained from a secondary of transformer T201. Diodes D207 thru D210 form a full-wave rectifier. Capacitors C203 thru C206 provide filtering of ac ripple.

g. Series Regulators. Transistors Q101 and Q105 form a complimentary-symmetry output stage. (These transistors are rated at 300 volts, 35 watts.) Transistors Q103 and Q106 are current limiting transistors which shut down the output transistors during a change in the selected polarity.

h. Range Resistor Controls. The Range Switch S101 selectes full range current from 10^{-7} to 10^{-1} amperes. Range resistors R184 thru R190 are selected such that, for each selected current, the voltage drop across the Range resistor R is 1 volt for full range.

i. Power Supplies. The remaining power supplies provide power to the amplifier stages and voltage references.

1. ±10 volts. Diodes D211 thru D214 form a full-wave rectifier which provides unregulated voltages for the ±10 volt regulator stages. Capacitors C207 and C208 provide filtering. Transistors Q209 and Q210 and reference zeners D205 and D206 form the ±10 volt regulators. This supply provides bias voltages for the voltage LIMIT indicator circuit.

2. ±12 volts. This supply provides power to the amplifier stages and reference diode D116. The supplies consist of a full-wave rectifier (Diodes D215 thru D218), an integrated circuit QA201, and a linear operational amplifier QA202. The voltage developed by QA201 is 24 volts. This output is split to form separate ±12 volt supplies. (These supplies are referenced to the output high.) Potentiometer R226 provides adjustment of the 24 volt output.

j. Modulation Circuit. The modulation circuit consists of transformer T101 which is connected so that the voltage feedback to amplifier "R1" can be modulated by an external source. Therefore the current output will likewise be modulated. The primary of T101 is connected between the center terminal of J101 and chassis ground.

3-4. SWITCHING. The OUTPUT SELECTOR Switch S105 has four positions labeled "-", "STANDBY", "STANDBY", and "+". The "-" and "+" positions connect the internal circuitry such that the polarity of the current at the "OUT" terminal can be changed with respect to "LOW". This is accomplished by reversing the polarity of the voltage references since amplifier "A3" is a bipolar amplifier. The two "STANDBY" positions permit a change of polarity to be made without developing large transients. The "STANDBY" positions connect the high output to "LOW" through a 10 milliohm shunt as shown in Figure 5. Since the selected current will be shunted through the 10 milliohms, up to 10 millivolts can be developed between the "OUT" and "LOW" terminals with no load. Resistor R193 limits the voltage drop to 1 millivolt for a 1 ohm load.

SECTION 4. ACCESSORIES

4-1. GENERAL. The following Keithley accessories can be used with the Model 225 to provide additional convenience and versatility.

4-2. OPERATING INSTRUCTIONS. A separate Instruction Manual is supplied with each accessory giving complete operating information.

Model 1004 Rack Mounting Kit

Description:

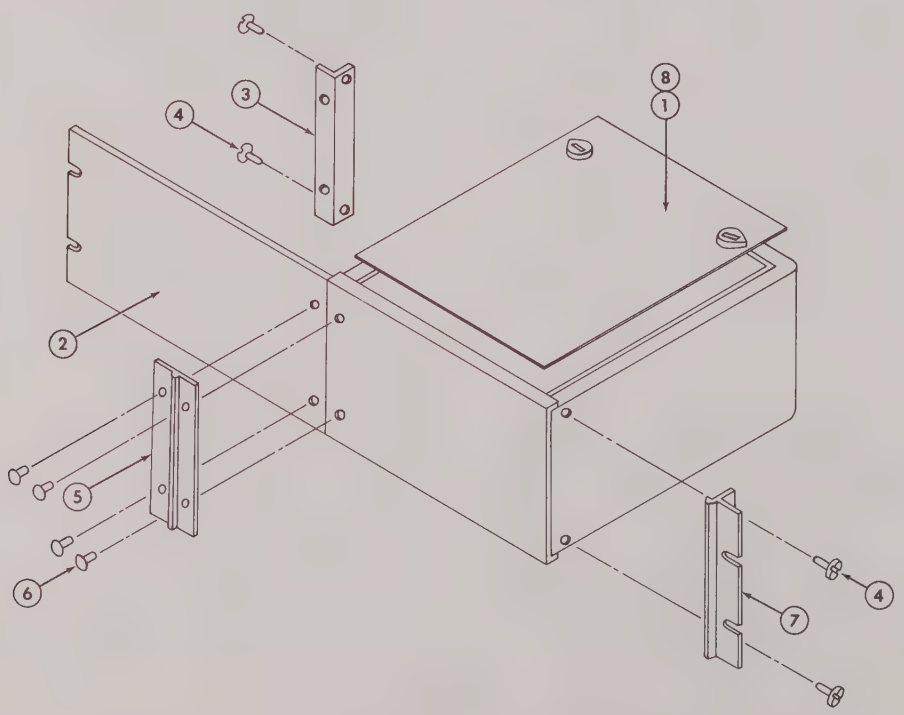
The Model 1004 is a rack mounting kit with overall dimensions 5-1/2 inches high x 19 inches wide x 10 inches deep.

Application:

The Model 1004 converts the instrument from bench to rack mounting. It is suitable for mounting one instrument in one-half of a standard 19-inch rack.

Parts List:

Item No.	Description	Qty. Per Assembly	Keithley Part No.
1	Top Cover	1	20016B
2	Panel	1	17452B
3	Angle	1	17476A
4	Screw	4	---
5	Plate	1	19126A
6	Screw	4	---
7	Angle	1	14624B



SECTION 5. SERVICING

5-1. GENERAL. This section contains procedures for checkout and servicing the instrument. Follow the step-by-step procedures for complete servicing.

5-2. SERVICING SCHEDULE. This instrument requires no periodic maintenance beyond the normal care required for high-quality electronic equipment.

5-3. PARTS REPLACEMENT. Refer to the Replaceable Parts List, Section 7, for information regarding component specifications and part numbers. Replace components as indicated using replacement parts which meet the listed specifications.

5-4. TROUBLESHOOTING.

a. Test Equipment. Refer to Table 5-1 for recommended test equipment for servicing and calibrating this instrument.

b. Troubleshooting Guide. Refer to Figure 16 for voltages and test points.

NOTE

If the instrument problem cannot be readily located or repaired, contact a Keithley representative or the Sales Service Department, Cleveland, Ohio.

TABLE 5-1.
Test Equipment.

Code Letter	Instrument Type	Specification	Manufacturer and Model No.	Use
A	Multimeter, Digital	Voltage: ±0.1% of reading. Current: ±0.2% of reading except ±0.3% of reading on 100 mA, 1 A ranges.	Keithley, Model 160	Accuracy check, General.
B	Electrometer	.001 V to 100 V $10^{14}\Omega$ input resistance.	Keithley, Model 610C	General.
C	Voltmeter, Differential	0.5 V to 500 V 100 μV null.	Keithley, Model 662	General.
D	Voltmeter, True RMS	0.1 mV to 300 V rms Freq. Resp. 10 to 4 MHz.	Keithley, Model 124	General.
E	Oscilloscope	DC-450 kHz, 1 mV/div.	Tektronix, Model 503	General.
F	Variac	0-130 V rms.	General Radio	Line Regulation.
G	Power Line Monitor	105-130 V rms.	-	General.
H	Oscillator	100 Hz, sine wave.	Wavetek.	Modulation Check.
J	Recorder	1 mA for full-scale deflection.	Keithley, Model 370.	Drift Check.
K	Load Fixture	1 kΩ/10 Ω - Resistors	See Text.	Load Regulation.
L	Inductive Load Fixture	1 mH Inductance	See Text.	Inductive Load Check.

SECTION 6. CALIBRATION

6-1. GENERAL. This section contains procedures for checking the instrument in order to verify operation within specifications.

6-2. TEST EQUIPMENT. Refer to Table 5-1 for recommended test equipment for servicing and calibrating this instrument.

6-3. CALIBRATION PROCEDURE. Refer to Table 6-1 for step-by-step procedures for calibrating this instrument.

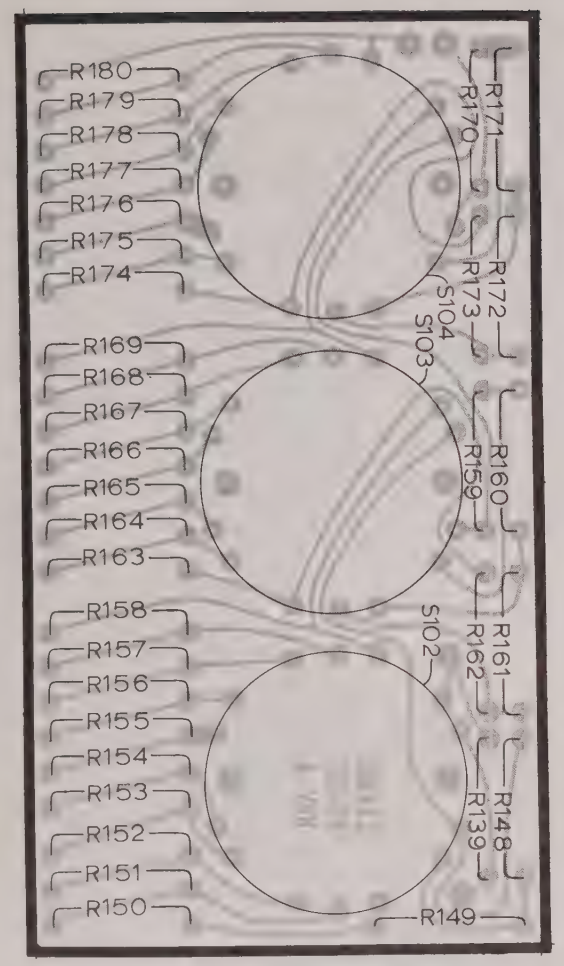
NOTE

If proper facilities and equipment are not available, contact a Keithley representative or the Sales Service Department, Cleveland, Ohio. Keithley Instruments, Inc. maintains a complete repair and calibration facility with equipment traceable to the National Bureau of Standards.

TABLE 6-1.
Performance Check

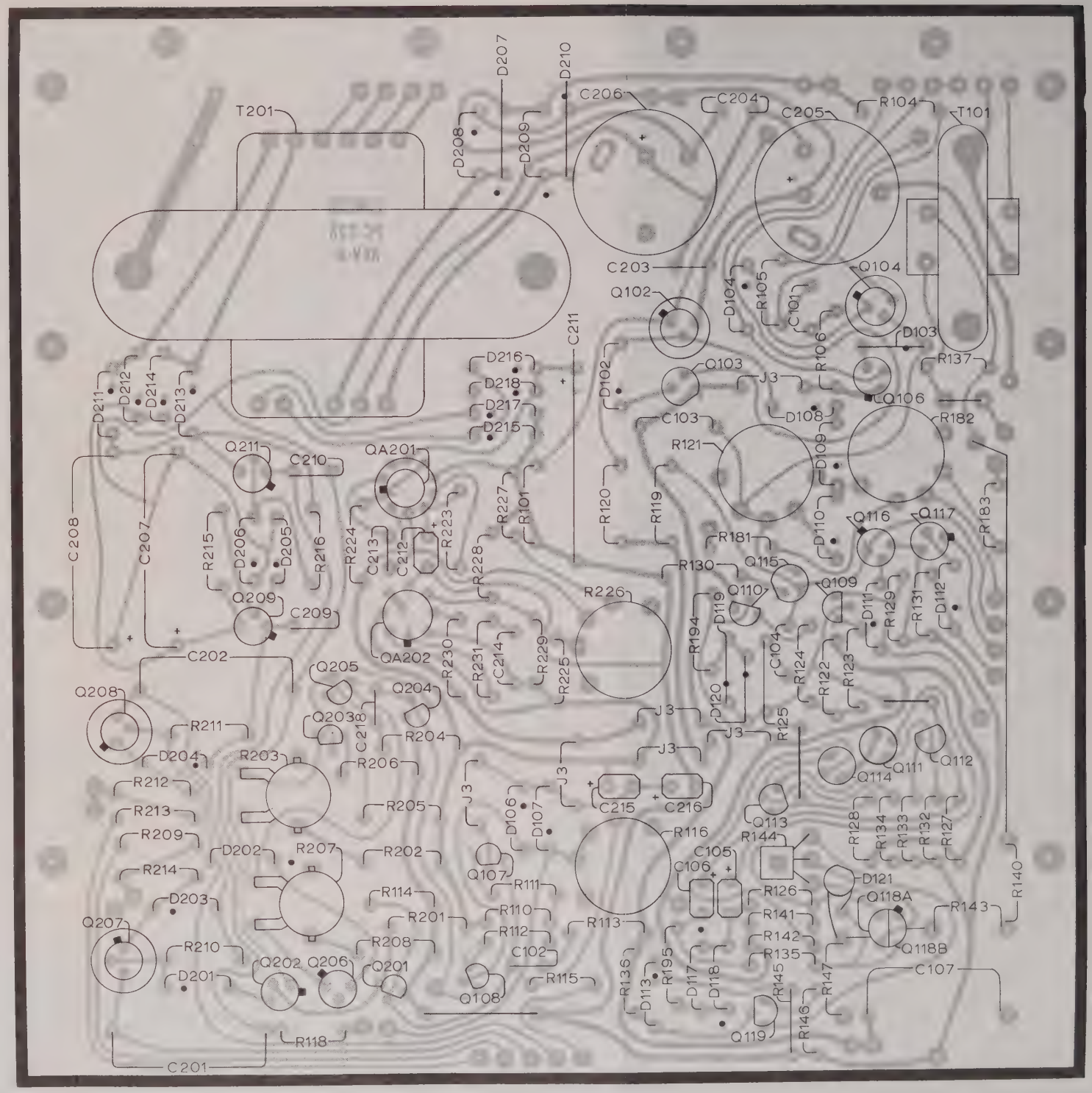
Para. 6-3	Specification or Adjustment	Description	Measurement	Figure
a.	Accuracy. NOTE: Line voltage 115V. Amb. Temp: 25°C. Rel. Humidity: 50%. Link between LOW and GROUND. FILTER: OFF.	Verify the accuracy on each full-scale range.		
		Set OUTPUT to STANDBY. Connect the Digital Multimeter (A) to OUT receptacle as shown in Figure 17. Set COMPLIANCE to 100. Set FINE to 0 (calibrated position).		17
		100 mA Range: Set decade dials to 9-9-9. Set range to 100 mA. Set OUTPUT to +. Measure current. Repeat for - OUTPUT.	Current reading should be 99.9 mA ±0.85 mA.*	
		10 mA Range: Set decade dials to 9-9-9. Set range to 10 mA. Set OUTPUT to +. Measure current. Repeat for - OUTPUT.	Current reading should be 9.99 mA ±.075 mA.**	
		1000 µA Range: Set decade dials to 9-9-9. Set range to 1000 µA. Set OUTPUT to +. Measure current. Repeat for - OUTPUT.	Current reading should be 999. µA ±7.5 µA.**	
		100 µA Range: Set decade dials to 9-9-9. Set range to 100 µA. Set OUTPUT to +. Measure current. Repeat for - OUTPUT.	Current reading should be 99.9 µA ±0.75 µA.**	
		10 µA Range: Set decade dials to 9-9-9. Set range to 10 µA. Set OUTPUT to +. Measure current. Repeat for - OUTPUT.	Current reading should be 9.99 µA ±0.075 µA.**	
		1000 nA Range: Set decade dials to 9-9-9. Set range to 1000 nA. Set OUTPUT to +. Measure current. Repeat for - OUTPUT.	Current reading should be 999. nA ±7.5 nA.**	
		100 nA Range: Set decade dials to 9-9-9. Set range to 100 nA. Set OUTPUT to +. Measure current. Repeat for - OUTPUT.	Current reading should be 99.9 nA ±0.75 nA. **	

* Includes ±0.3% accuracy of the Model 160 (see Table 5-1).
** Includes ±0.2% accuracy of the Model 160 (see Table 5-1).



Component Layout, PC-227 (Switch Board)

FIGURE 13.



Component Layout, PC-228 (Mother Board)

FIGURE 14.

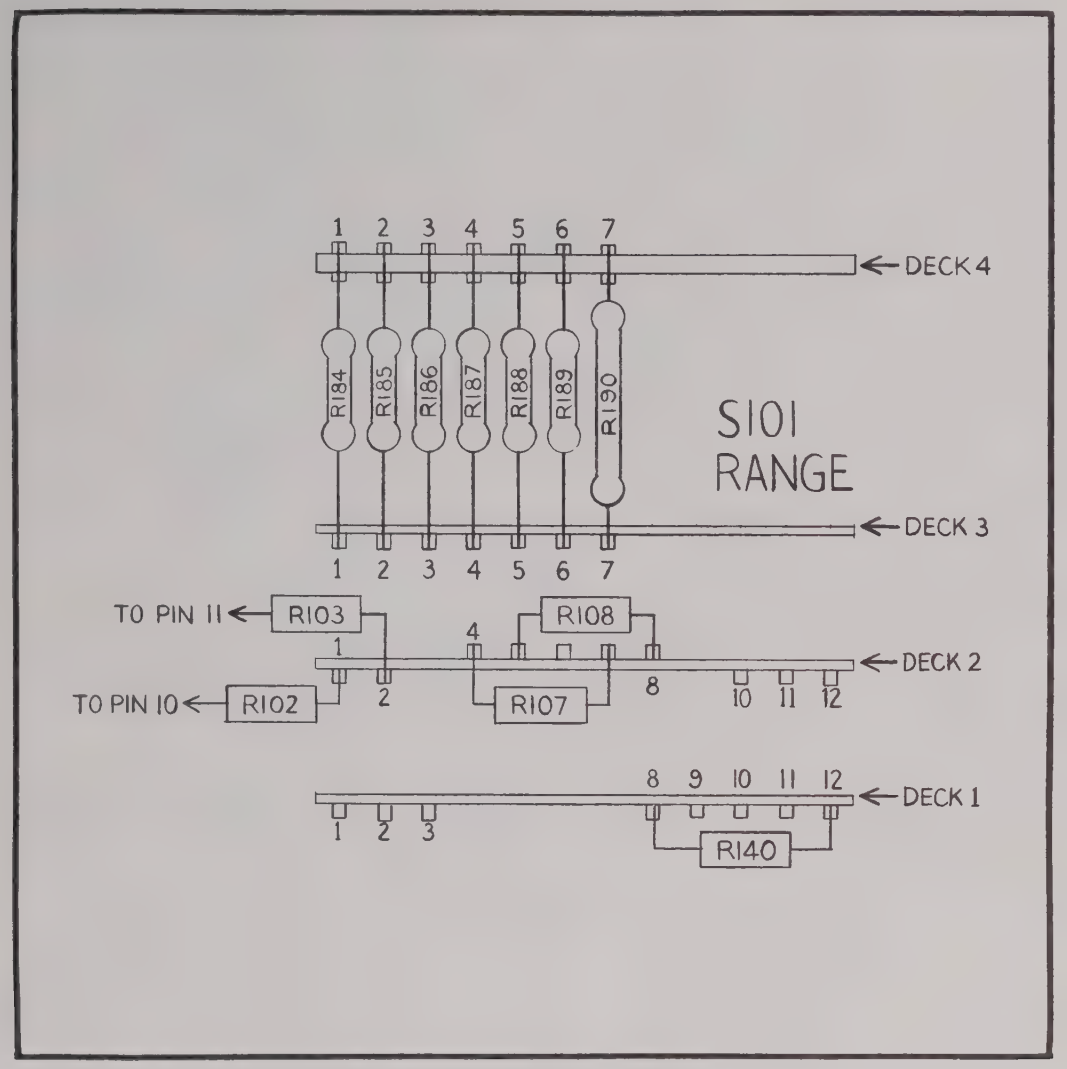


FIGURE 15. Component Layout, Switch S101.

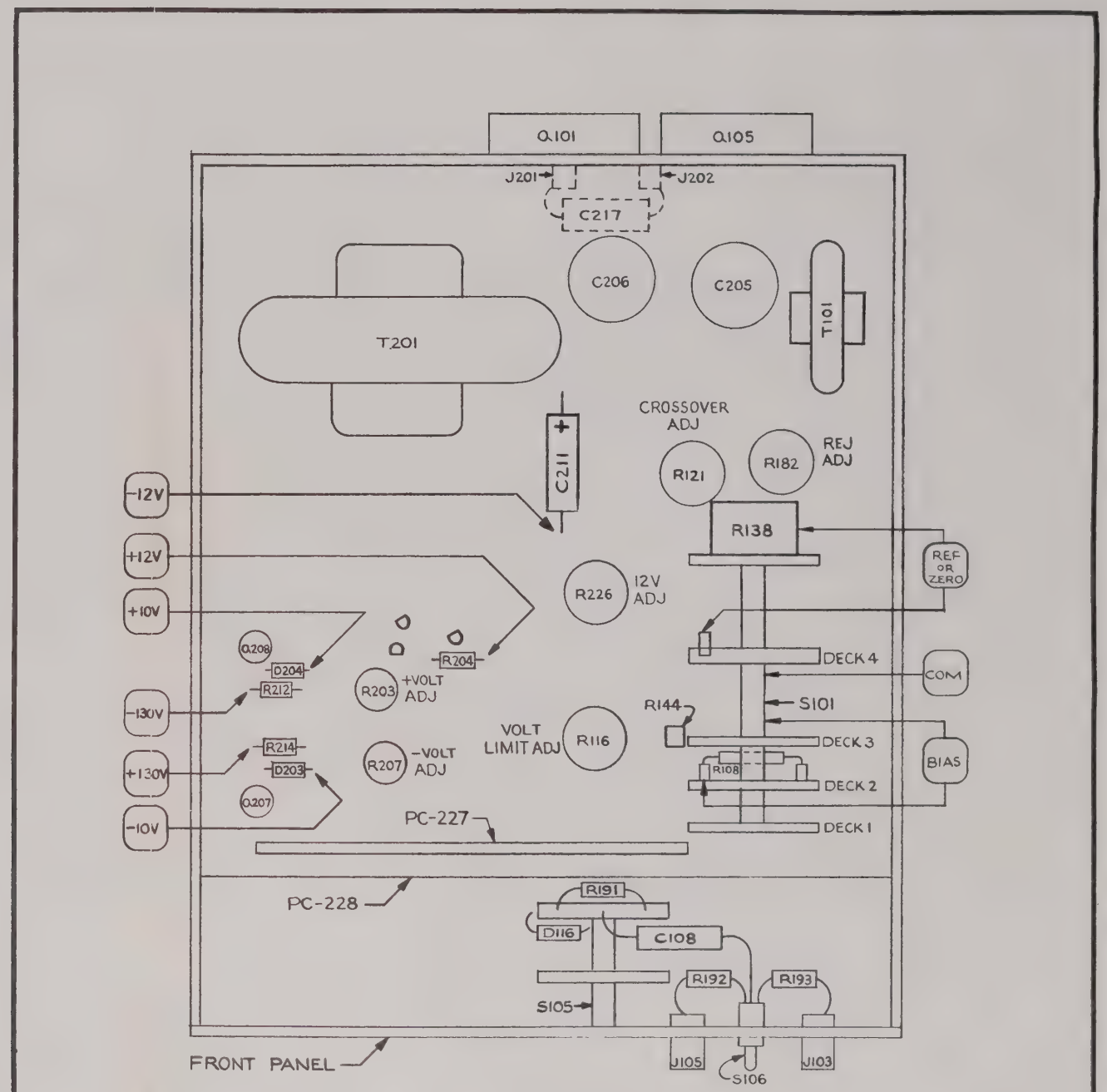


FIGURE 16. Chassis - Top View.

TABLE 6-1. (Cont'd)

Para. 6-3	Specification or Adjustment	Description	Measurement	Figure
b.	Line Regulation. NOTE: Line voltage: 115V. Amb. Temp: 25°C. Rel. Humidity: 50%. Link between LOW and GROUND. FILTER: OFF.	Verify line regulation.		
		Set OUTPUT to STANDBY. Set decade dials to 9-9-9. Connect load resistor between front panel LOW and OUT as shown in Figure 18. Set COMPLIANCE to 100. Set FINE to 0. Set range to 100 mA.		18
		Set line voltage to 105 V. Set OUTPUT to +. Measure voltage at load. Repeat for - OUTPUT.	Voltage change should not exceed 50 μV.	
		Set line voltage to 125V.	Voltage change should not exceed 50 μV.	
c.	Load Regulation. NOTE: Line voltage: 115V. Amb. Temp: 25°C. Rel. Humidity: 50%. Link between LOW and GROUND. FILTER: OFF.	Verify load regulation.		
		Set OUTPUT to STANDBY. Set decade dials to 9-9-9. Set FINE to 0. Set range to 100 mA. Set COMPLIANCE to 100. Set line voltage to 115 V.		
		Connect load resistor between front panel LOW and OUT as shown in Figure 18. Set OUTPUT to +. Measure voltage at load. Repeat for - OUTPUT.	Voltage change should not exceed 50 μV.	18
d.	Noise Check.	Set OUTPUT to STANDBY. Set decade dials to 9-9-9. Set FINE to 0. Set range to 100 mA. Set COMPLIANCE to 100. Connect load resistor. Set OUTPUT to +. Measure rms noise using Voltmeter (D). Repeat for - OUTPUT.	Noise should be less than 10 mV rms.	
e.	Modulation.	Set range to 100 mA. Set decade dials to 5-0-0. Set FINE to 0. Set COMPLIANCE to 100. Connect Oscillator (H) to MODULATE input. Connect Oscilloscope ( ) and load resistor to OUT as shown in Figure 19. Set Oscillator (H) for 30 V p-p @ 100 Hz. Waveform should be a 400 mV p-p modulated wave.	400 mV p-p.	19
f.	Inductive Loading.	Set range to 100 mA. Set decade dials to 9-9-9. Set FINE to 0. Set COMPLIANCE to 100. Set FILTER to ON. Connect inductive load. (1 mH in series with 1 kΩ) as shown in Figure 20. Set OUTPUT to +. Connect Oscilloscope (H) and measure ripple. Voltage should be less than 100 mV p-p. Set FILTER to OFF. No oscillations should occur.		20
g.	Drift Check.	Set range to 1000 μA. Set decade dials to 9-9-9. Set FINE to 0. Set OUTPUT to STANDBY. Warm-up 225 for 1 Hr. Connect Recorder to OUT. Set OUTPUT to +. Adjust FINE for 1 V deflection on recorder. Total drift for 1st hour should not exceed ±250 mV with less than 100 mV/°C.		

TABLE 6-2.
Calibration Procedures

Para. 6-4	Specification or Adjustment	Description	Measurement	Sub-Assembly	Figure	Test Point	Schematic Part No.
a.	Power Supplies.NOTE: DC voltmeter and oscilloscope must be floated for measurement of 12V supplies. Line Voltage: 117V. Link between LOW and GROUND. LINE SWITCH: 117V.	Calibrate power supply.					
		-12 VOLTS DC: Measure -12V supply with respect to range switch shaft. (common). Adjust potentiometer R226 for -12V ±0.01V.	Adjust for voltage of -12V ± 0.01V. Ripple should be less than 3 mV p-p.	PC-228 Potentiometer R226.	14,16	-12V	24203E
		+12 VOLTS DC: Measure +12V supply with respect to range switch shaft. (common).	Voltage should be +12V ±0.24V. Ripple should be less than 3 mV p-p.	PC-228	14,16	+12V	24203E
		NOTE: If 234V power is used, set LINE SWITCH to 234V.					
		-10 VOLTS DC: Measure -10V with respect to LOW. Ripple should be less than 20 mV p-p.	Voltage should be -10V ±1V.	PC-228	14,16	-10V	24203E
		+10 VOLTS DC: Measure +10V with respect to LOW. Ripple should be less than 20 mV p-p.	Voltage should be +10V ±1V.	PC-228	14,16	+10V	24203E
b.	Amplifier Zero	Set range to nA. Set decade dials to 0-0-0. Set OUTPUT to STANDBY. Set COMPLIANCE to 100. Connect Digital Voltmeter (A) between test points shown in Figure 16. Adjust potentiometer R144 for zero.	Adjust for 0 ±0.1 mV.	PC-228 Potentiometer R144.	14,16	-	24204E
c.	Reference	Set range to mA. Set decade dials to 9-9-9. Set FINE to 10. Set OUTPUT to + STANDBY. Set COMPLIANCE to 100. Connect Digital Voltmeter (A) between test points shown in Figure 16. Adjust potentiometer R182 for +1.0 ±0.5 mV.	Adjust for +1.0V ±0.5 mV.	PC-228 Potentiometer R182.	14,16	-	24204E
		Set OUTPUT to - STANDBY.	Voltage change must not exceed 1 mV.				
d.	Bias	Set range to nA. Set decade dials to 9-9-9. Set FINE to 10. Set COMPLIANCE to 100. Set OUTPUT to - STANDBY. Connect Digital Voltmeter between test points shown in Figure 16. Adjust potentiometer R121 for voltage between 27 mV to 40 mV. (This sets current thru transistors Q101, Q102).	Adjust for voltage between 27 mV to 40 mV.	PC-228	14,16	-	24204E

TABLE 6-2. (CONT'D)

Para. 6-4	Specification or Adjustment	Description	Measurement	Sub-Assembly	Figure	Test Point	Schematic Part No.
e.	Compliance	Set range to mA. Set decade dials to 9-9-9. Set FINE to 10. Set COMPLIANCE to 100. Set OUTPUT to + STANDBY. Connect Digital Voltmeter (A) between range switch shaft (12V common) and LOW. Connect load resistor. Adjust potentiometer R116 for 101.V ±10 mV.	Adjust for voltage of 101.V ±10 mV.	PC-228 Potentiometer R116.	14,16	COMMON	24204E
f.	Voltage Limit Lamp	Set range to mA. Set decade dials to 9-9-9. Set FINE to 10. Set COMPLIANCE to 10. Set OUTPUT to + STANDBY. Connect Oscilloscope (E) to OUT. Oscilloscope Settings: 2mV/div 5mS/div Trigger = INTERNAL Input = AC COUPLED					
		Connect load resistor. Set OUTPUT to +. Adjust potentiometer R203 such that the LIMIT lamp turns on when the 225 changes from current mode to voltage mode.	-	PC-228 Potentiometer R203.	14,16	-	24203E
		NOTE: To determine the crossover point between current and voltage modes, adjust the COMPLIANCE control until the oscilloscope ripple waveform changes as shown in Figure 21.					
		Set OUTPUT to -. Adjust potentiometer R207 such that the LIMIT lamp turns on when the 225 changes from current mode to voltage mode.		PC-228 Potentiometer R207.			24203E

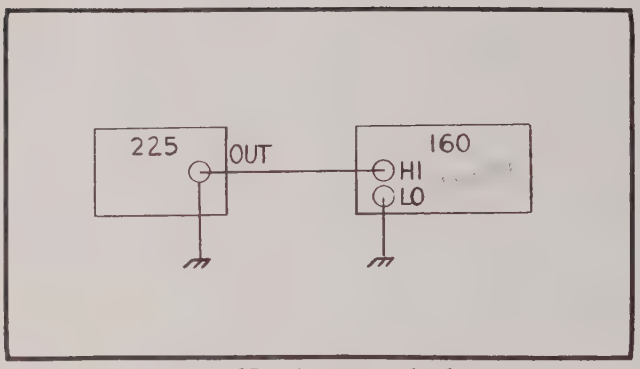


FIGURE 17. Accuracy Check

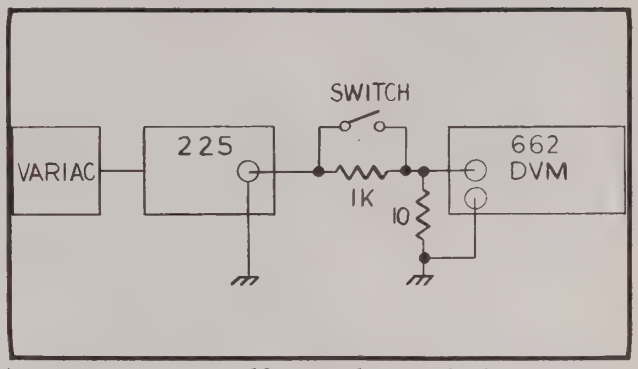


FIGURE 18. Regulation Check

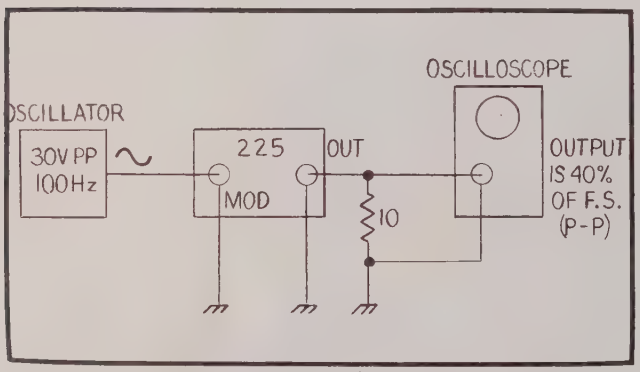


FIGURE 19. Modulation Check

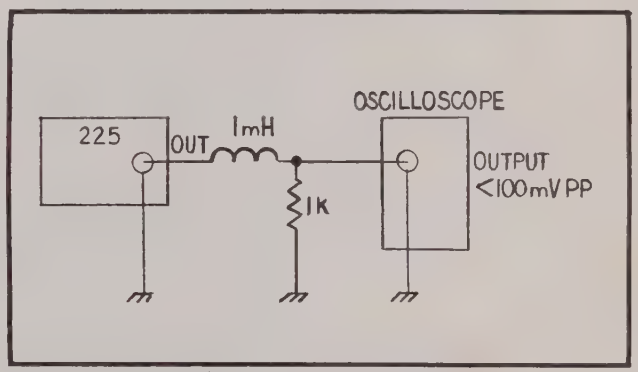


FIGURE 20. Inductive Load Check

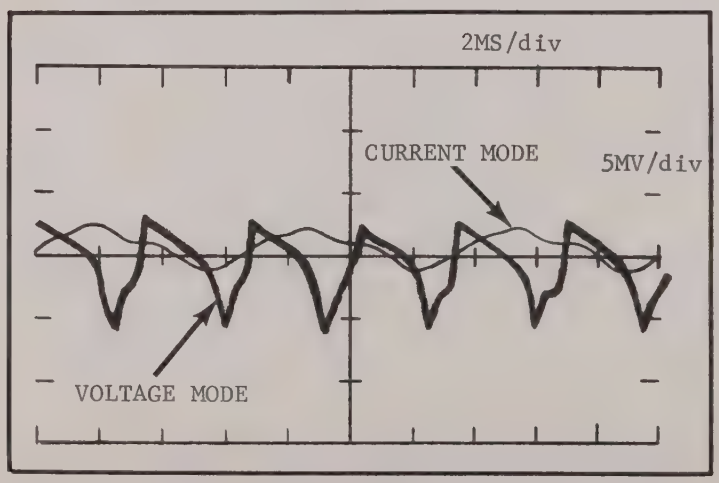


FIGURE 21. Current Mode Vs Voltage Mode Waveforms

SECTION 7. REPLACEABLE PARTS

7-1. REPLACEABLE PARTS LIST: This section contains a list of components used in this instrument for user reference. The Replaceable Parts List describes the individual parts giving Circuit Designation, Description, Suggested Manufacturer (Code Number), Manufacturer's Part Number, and the Keithley Part Number. Also included is a Figure Reference Number where applicable. The complete name and address of each Manufacturer is listed in the CODE-TO-NAME Listing following the parts list.

TABLE 7-1.
Abbreviations and Symbols

A	ampere	F	farad	Ω	ohm
		Fig	Figure		
CbVar	Carbon Variable			p	pico (10^{-12})
CerD	Ceramic Disc	GCb	Glass enclosed Carbon	PC	Printed Circuit
CerTB	Ceramic Tubular			Poly	Polystyrene
Cer Trimmer	Ceramic Trimmer	k	kilo (10^{3})		
Comp	Composition			Ref.	Reference
		μ	micro (10^{-6})		
DCb	Deposited Carbon			TCu	Tinner Copperweld
Desig.	Designation	M	Meg (10^{6})		
		Mfr.	Manufacturer	V	volt
EAL	Electrolytic, Aluminum	MtF	Metal Film		
ETB	Electrolytic, Tubular	My	Mylar	W	watt
ETT	Electrolytic, Tantalum			WW	Wirewound
		No.	Number	WWVar	Wirewound Variable

7-2. ELECTRICAL SCHEMATICS AND DIAGRAMS. Schematics and diagrams are included to describe the electrical circuits as discussed in Section 3. Table 7-2 identifies all schematic part numbers included.

7-3. HOW TO USE THE REPLACEABLE PARTS LIST. This Parts List is arranged such that the individual types of components are listed in alphabetical order. Main Chassis parts are listed followed by printed circuit boards and other subassemblies.

7-4. HOW TO ORDER PARTS.

a. Replaceable parts may be ordered through the Sales Service Department, Keithley Instruments, Inc. or your nearest Keithley representative.

b. When ordering parts, include the following information.

1. Instrument Model Number
2. Instrument Serial Number
3. Part Description
4. Schematic Circuit Designation
5. Keithley Part Number

c. All parts listed are maintained in Keithley Spare Parts Stock. Any part not listed can be made available upon request. Parts identified by the Keithley Manufacturing Code Number 80164 should be ordered directly from Keithley Instruments, Inc.

TABLE 7-2.
Schematics

Description	Assembly No.	Schematic No.
Amplifier	PC-227, PC-228	24204E
Power Supply	PC-228	24203E

TABLE 7-3.
Circuit Designation Series

Series	Description	Circuit Designation	Page No.
100	Amplifier	PC-227, PC-228	22
200	Power Supply	PC-228	27

TABLE 7-4.
Mechanical Parts List

Description	Quantity Per Assembly	Keithley Part No.	Fig. No.
1) Chassis	1	24021B	22
11) Front Panel	1	23396C	
Top Cover Assembly	---	24563B	22
12) Cover, Sheet Metal	1	24561D	
13) Screws	4	---	
Handle Assembly	---	---	
14) Handle	1	HH-18	
15) Screws #6-32 x 3/8" R.H. Slotted	2	---	
Bottom Cover Assembly	---	17148C	23
2) Cover	1	17149C	
3) Fastener	2	FA-54	
Feet Assembly	---	---	
4) Feet	4	FE-5	
5) Ball	4	FE-6	
6) Screws #8-32 x 3/8" Phillips, Pan Head	4	---	
Tilt Bail Assembly	---	---	
7) Bail	1	17147B	
8) Right Assembly	1	19206B	
9) Left Assembly	1	19205B	
10) Screws #6-32 x 1/4" Phillips, Pan Head	2	---	

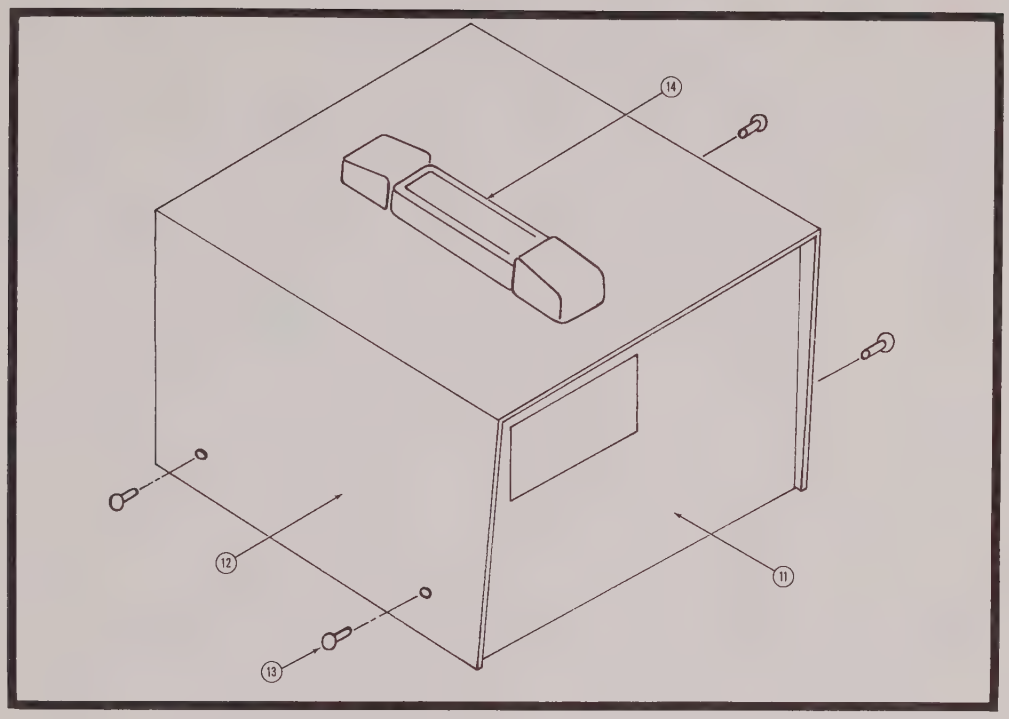


FIGURE 22. Top Cover Assembly.

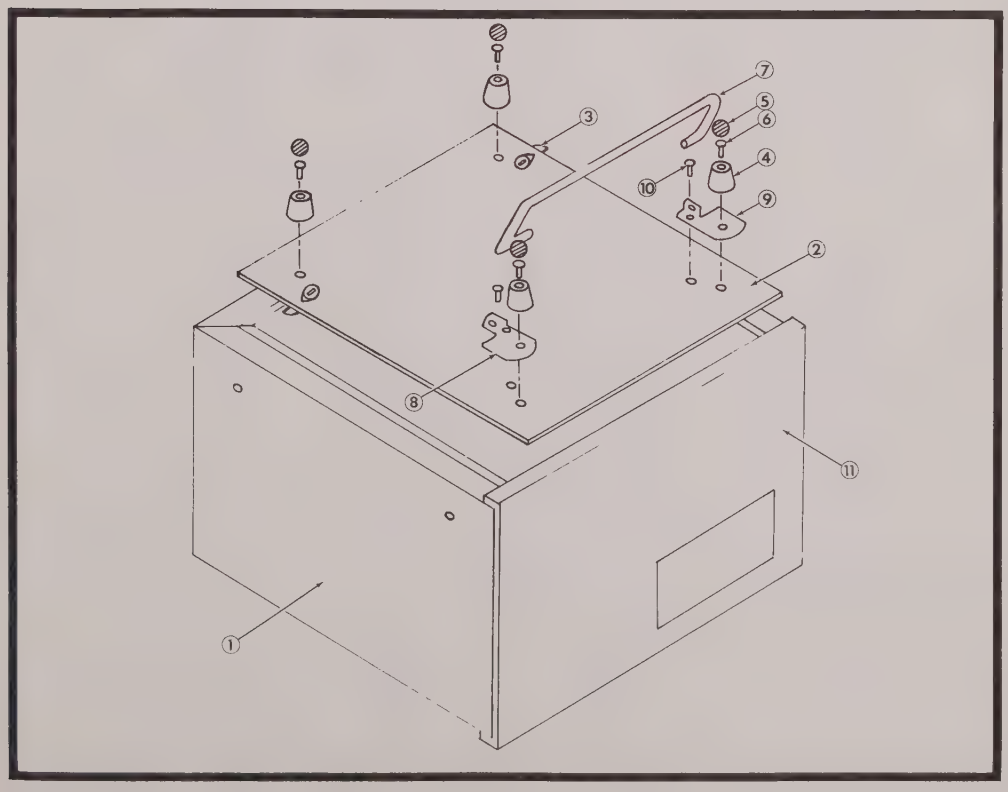


FIGURE 23. Bottom Cover Assembly.

REPLACEABLE PARTS LIST
AMPLIFIER, "100" SERIES, PC-228

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
C101	.0068 μF	600V	CerD	72982	ED-.0068	C22-.0068M	14
C102	.0022 μF	600V	CerD	72982	ED-.0022	C22-.0022M	14
C103	.22 μF	50V	My	84411	601PE	C41-.22M	14
C104	.02 μF	600V	CerD	72982	ED-.02	C22-.02M	14
C105	4.7 μF	20V	ETT	17554	TSD1-20-475	C179-4.7M	14
C106	4.7 μF	20V	ETT	17554	TSD1-20-475	C179-4.7M	14
C107	1 μF	200V	My	13050	107-21	C66-1M	14
C108	1 μF	200V	My	13050	107-21	C66-1M	16
C109	.02μF	600V	CerD	72982	ED-.02	C-22-.02	
C110	33pF	1000V	CerD	71590	DD-330	C-64-33p	

CONNECTORS

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
J101	Receptacle, BNC, MODULATE (Mil. No. UG-1094/U)	02660	31-221	CS-15	2
J102	Not Used				
J103	Receptacle, BNC, Front Panel OUT (Mil. No. UG-1094/U)	02660	31-221	CS-15	2
J104	Receptacle, BNC, Rear Panel OUT (Mil. No. UG-1094/U)	02660	31-221	CS-15	2
J105	Receptacle, BNC, Front Panel LOW (Mil. No. UG-1094/U)	02660	31-221	CS-15	2
J201	Binding Post, GROUND	58474	DF21BC	BP-11B	2
J202	Binding Post, Rear Panel LOW	58474	DF21GC	BP-11G	2

DIODES

Circuit Desig.	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
D101	Not Used				
D102	Silicon	01295	1N645	RF-14	14
D103	Silicon	01295	1N645	RF-14	14
D104	Silicon	01295	1N645	RF-14	14
D105	Not Used				
D106	Silicon	01295	1N645	RF-14	14
D107	Silicon	01295	1N645	RF-14	14
D108	Silicon	01295	1N645	RF-14	14
D109	Silicon	01295	1N645	RF-14	14
D110	Silicon	01295	1N645	RF-14	14
D111	Silicon	01295	1N645	RF-14	14
D112	Silicon	01295	1N645	RF-14	14
D113	Silicon	01295	1N645	RF-14	14
D114	Not Used				
D115	Not Used				
D116	Zener, 6.2V, 1/4W	12954	1N827A	DZ-48	16
D117	Silicon	01295	1N914	RF-28	14
D118	Silicon	01295	1N914	RF-28	14
D119	Silicon	01295	1N914	RF-28	14
D120	Silicon	01295	1N914	RF-28	14
D121*		...		24555A*	14

*Selected from Keithley Part No. TG-39, NPN transistor, connected base to emitter

MISCELLANEOUS PARTS

Circuit Desig.	Description	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
DS101	Pilot Light, LIMIT	91802	2100	PL-38	2
DS201	Pilot Light, Decimal	91802	2140	PL-47	2
DS202	Pilot Light, Decimal	91802	2140	PL-47	2
DS203	Pilot Light, Decimal	91802	2140	PL-47	2
F201(117V)	Fuse, 3AG Slow Blow, 1/4A	75915	313.250	FU-17	2
F201(234V)	Fuse, 3AG Slow Blow, 1/8A	71400	MDL	FU-20	2
---	Fuse Holder	75915	342012	FH-3	2
P201	Power Cord, 6 feet	93656	4638-13	CO-5	2
---	Strain relief for P201	28520	SR-5P-1	CC-4	2
QA201	Integrated Circuit	07263	65R7723393A723C	IC-14	2
QA202	Linear Integrated Circuit	04713	MC1439G	IC-13	2
T101	Modulation Transformer	80164	TR-125	TR-125	2
T201	Power Transformer	80164	TR-124	TR-124	2

TRANSISTORS

Circuit Desig.	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
Q101*	80164	40318	24560A	14
Q102	04713	MM3003	TG-58	14
Q103	07263	2N3565	TG-39	14
Q104	04713	MM4003	TG-59	14
Q105*	80164	40318	24560A	14
Q106	07263	2N3638	TG-33	14
Q107	04713	2N3905	TG-53	14
Q108	04713	2N3905	TG-53	14
Q109	04713	2N3905	TG-53	14
Q110	04713	2N3905	TG-53	14
Q111**	80164	A-642L	TG-64	14
Q112	07263	2N3565	TG-39	14
Q113	07263	2N3565	TG-39	14
Q114**	80164	A-642L	TG-64	14
Q115	07263	2N3565	TG-39	14
Q116	07263	2N3638	TG-33	14
Q117	07263	2N3638	TG-33	14
Q118A***	80164	2N5452	24670A	14
Q118B***	80164	2N5452	24670A	14
Q119	04713	2N3903	TG-49	14

* Specially selected transistor; order singly.
** Matched pair; order as a pair.
***Matched pair with heat sink; order as a pair.

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
R101	12 kΩ	10%, 1/2 W	Comp	01121	EB	R1-12K	14
R102	3.9 Ω	10%, 1/2 W	Comp	01121	EB	R1-3.9	15
R103	18 Ω	10%, 1/2 W	Comp	01121	EB	R1-18	15
R104	100 Ω	10%, 1/2 W	Comp	01121	EB	R1-100	14
R105	180 Ω	10%, 1/4 W	Comp	01121	CB	R76-180	14
R106	470 Ω	10%, 1/2 W	Comp	01121	EB	R1-470	14
R107	3.9 Ω	10%, 1/2 W	Comp	01121	EB	R1-3.9	15
R108	27 Ω	10%, 1/2 W	Comp	01121	EB	R1-27	15
R109	Not Used						
R110	37.4 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-37.4K	14
R111	402 Ω	1%, 1/8 W	MtF	07716	CEA	R88-402	14
R112	402 Ω	1%, 1/8 W	MtF	07716	CEA	R88-402	14
R113	100 Ω	10%, 1/2 W	Comp	01121	EB	R1-100	14
R114	15 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-15K	14
R115	5.49 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-5.49K	14
R116	2 kΩ	20%, 2W	WWVar	71450	1NS 115	RP50-2K	14
R117	50 kΩ	10%, 3W	WWVar	12697	58	RP80-50K	14
R118	5.1 kΩ	5%, 3W	WW	44655	200	R173-5.1K	14
R119	22 kΩ	10%, 1/2 W	Comp	01121	EB	R1-22K	14
R120	10 kΩ	10%, 1/2 W	Comp	01121	EB	R1-10K	14
R121	1 kΩ	20%, 2W	WWVar	71450	1NS 115	RP50-1K	14
R122	8.2 kΩ	10%, 1/2 W	Comp	01121	EB	R1-8.2K	14
R123	390 Ω	10%, 1/2 W	Comp	01121	EB	R1-390	14
R124	390 Ω	10%, 1/2 W	Comp	01121	EB	R1-390	14
R125	4.7 kΩ	10%, 1/2 W	Comp	01121	EB	R1-4.7K	14
R126	20 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-20K	14
R127	20 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-20K	14
R128	20 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-20K	14
R129	20 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-20K	14
R130	2.2 kΩ	10%, 1/2 W	Comp	01121	EB	R1-2.2K	14
R131	20 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-20K	14
R132	20 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-20K	14
R133	49.9 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-49.9K	14
R134	20 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-20K	14
R135	20 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-20K	14
R136	100 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-100K	14
R137	499 Ω	1%, 1/8 W	MtF	07716	CEA	R88-499	14
R138	500 Ω	1%, 1/2 W	Var	71450	GC-T450	RP91-500	14
R139	95.3 Ω	1%, 1/2 W	MtF	07716	CEC	R94-95.3	13
R140	100 Ω	10%, 1/2 W	Comp	01121	EB	R1-100K	15
R141	182 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-182K	14
R142	182 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-182K	14
R143	10 kΩ	10%, 1/2 W	Comp	01121	EB	R1-10K	14
R144	500 Ω	20%, 3/4 W	Cermet	73138	77PR500	RP64-500	14
R145	49.9 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-49.9K	14
R146	49.9 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-49.9K	14
R147	10 kΩ	10%, 1/2 W	Comp	01121	EB	R1-10K	14
R148	40.2 Ω	1%, 1/2 W	MtF	07716	CEC	R94-40.2	13
R149	40.2 Ω	1%, 1/2 W	MtF	07716	CEC	R94-40.2	13
R150	40.2 Ω	1%, 1/2 W	MtF	07716	CEC	R94-40.2	13
R151	40.2 Ω	1%, 1/2 W	MtF	07716	CEC	R94-40.2	13
R152	40.2 Ω	1%, 1/2 W	MtF	07716	CEC	R94-40.2	13

RESISTORS (Cont'd.)

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
R153	40.2 Ω	1%, 1/2 W	MtF	07716	CEC	R94-40.2	13
R154	40.2 Ω	1%, 1/2 W	MtF	07716	CEC	R94-40.2	13
R155	40.2 Ω	1%, 1/2 W	MtF	07716	CEC	R94-40.2	13
							13
R156	40.2 Ω	1%, 1/2 W	MtF	07716	CEC	R94-40.2	13
R157	40.2 Ω	1%, 1/2 W	MtF	07716	CEC	R94-40.2	13
R158	40.2 Ω	1%, 1/2 W	MtF	07716	CEC	R94-40.2	13
R159	200 Ω	1/4%, 1/2 W	MtF	07716	CEC-TO	R127-200	13
R160	200 Ω	1/4%, 1/2 W	MtF	07716	CEC-TO	R127-200	13
R161	200 Ω	1/4%, 1/2 W	MtF	07716	CEC-TO	R127-200	13
R162	200 Ω	1/4%, 1/2 W	MtF	07716	CEC-TO	R127-200	13
R163	200 Ω	1/4%, 1/2 W	MtF	07716	CEC-TO	R127-200	13
R164	200 Ω	1/4%, 1/2 W	MtF	07716	CEC-TO	R127-200	13
R165	200 Ω	1/4%, 1/2 W	MtF	07716	CEC-TO	R127-200	13
R166	200 Ω	1/4%, 1/2 W	MtF	07716	CEC-TO	R127-200	13
R167	200 Ω	1/4%, 1/2 W	MtF	07716	CEC-TO	R127-200	13
R168	200 Ω	1/4%, 1/2 W	MtF	07716	CEC-TO	R127-200	13
R169	200 Ω	1/4%, 1/2 W	MtF	07716	CEC-TO	R127-200	13
R170	1 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-1K	13
R171	1 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-1K	13
R172	1 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-1K	13
R173	1 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-1K	13
R174	1 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-1K	13
R175	1 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-1K	13
R176	1 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-1K	13
R177	1 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-1K	13
R178	1 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-1K	13
R179	1 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-1K	13
R180	1 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-1K	13
R181	1 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-1k	14
R182	200 Ω	20%, 2 W	WWVar	71450	1NS 115	RP50-200	14
R183	4.99 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-4.99K	14
R184	10 Ω	0.1%, 1/4 W	WW	01686	7009	R95-10	15
R185	100 Ω	0.1%, 1/2 W	MtF	91637	MFF	R169-100	15
R186	1 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-1K	15
R187	10 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-10K	15
R188	100 kΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-100K	15
R189	1 MΩ	0.1%, 1/2 W	MtF	91637	MFF	R169-1M	15
R190	10 MΩ	1/4%, 2 W	MtF	91637	MFF-2	R161-10M	15
R191	681 Ω	1%, 1/8 W	MtF	07716	CEA	R88-681	16
R192	100 kΩ	10%, 1/2 W	Comp	01121	EB	R1-100K	16
R193	10 Ω	10%, 1/2 W	Comp	01121	EB	R1-10	16
R194	220 Ω	10%, 1/2 W	Comp	01121	EB	R1-220	14
R195	220 Ω	10%, 1/2 W	Comp	01121	EB	R1-220	14

SWITCHES

Circuit Desig.	Description	Mfr. Code	Keithley Part No.	Fig. Ref.
S101	Rotary Switch less components, Range	80164	SW-284	2
---	Knob Assembly, Range Switch	80164		2
S102	Rotary Switch less components, first Decade Switch	80164	SW-282	2
---	Knob Assembly, first Decade Switch	80164	23603A	2
S103	Rotary Switch less components, second Decade Switch	80164	SW-282	2
---	Knob Assembly, second Decade Switch	80164	23603A	2
S104	Rotary Switch less components, third Decade Switch	80164	SW-282	2
---	Knob Assembly, third Decade Switch	80164	23603A	2
S105	Rotary Switch, OUTPUT SELECTOR Switch	80164	SW-283	2
---	Knob, OUTPUT SELECTOR Switch			
S106	Toggle Switch, FILTER	80164	SW-309	2
S201	Slide Switch, LINE	80164	SW-151	2
S202	Toggle Switch, Power	80164	SW-4	2

POWER SUPPLY, "200 SERIES

CAPACITORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
C201	Not Used	-----	-----	-----	-----	-----	--
C202	.5 µF	400 V	My	13050	SM1A	C117-.5M	14
C203	.001 µF	600 V	CerD	72982	ED-.001	C22-.001M	14
C204	.001 µF	600 V	CerD	72982	ED-.001	C22-.001M	14
C205	140 µF	150 V	EMC	56289	Type 630	C183-140M	14
C206	140 µF	150V	EMC	56289	Type 630	C183-140M	14
C207	100 µF	40V	EAL	73445	C437AR/G100	C150-100M	14
C208	100 µF	40V	EAL	73445	C437AR/G100	C150-100M	14
C209	.001 µF	600V	CerD	72982	ED-.001	C22-.001M	14
C210	.001 µF	600V	CerD	72982	ED-.001	C22-.001M	14
C211	100 µF	40V	EAL	73445	C437AR/G100	C150-100M	14
C212	4.7 µF	20V	ETT	17554	TSD1-20-475	C179-4.7M	14
C213	100 pF	600V	CerD	72982	ED-100	C22-100P	14
C214	.02 µF	600V	CerD	72982	ED-.02	C22-.02M	14
C215	10 µF	20V	ETT	17554	TSD2-20-106	C179-10M	14
C216	10 µF	20V	ETT	17554	TSD2-20-106	C179-10M	14
C217	.05 µF	600V	My	56289	6PS-550	C62-.05M	14
C218	150 pF	600V	CerD	72982	ED-150	C22-150P	14
C219	470 pF	1000V	CerD	71590	DD-471	C64-470P	

DIODES

Circuit Desig.	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
D201	Silicon	01295	1N645	RF-14	14
D202	Silicon	01295	1N645	RF-14	14
D203	Zener	12954	1N709	DZ-21	14
D204	Zener	12954	1N709	DZ-21	14
D205	Zener	12954	1N715	DZ-22	14
D206	Zener	12954	1N715	DZ-22	14
D207	Rectifier, 1A, 800V	04713	1N4006	RF-38	14
D208	Rectifier, 1A, 800V	04713	1N4006	RF-38	14
D209	Rectifier, 1A, 800V	04713	1N4006	RF-38	14
D210	Rectifier, 1A, 800V	04713	1N4006	RF-38	14
D211	Silicon	01295	1N645	RF-14	14
D212	Silicon	01295	1N645	RF-14	14
D213	Silicon	01295	1N645	RF-14	14
D214	Silicon	01295	1N645	RF-14	14
D215	Silicon	01295	1N645	RF-14	14
D216	Silicon	01295	1N645	RF-14	14
D217	Silicon	01295	1N645	RF-14	14
D218	Silicon	01295	1N645	RF-14	14

RESISTORS

Circuit Desig.	Value	Rating	Type	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
R201	4.7 kΩ	10%, 1/2 W	Comp	01121	EB	R1-4.7k	14
R202	6.8 kΩ	10%, 1/2 W	Comp	01121	EB	R1-6.8k	14
R203	2 kΩ	0.1%, 1/2 W	WW	54294	SP23D18	R67-2k	14
R204	4.7 kΩ	10%, 1/2 W	Comp	01121	EB	R1-4.7k	14
R205	2.2 kΩ	10%, 1/2 W	Comp	01121	EB	R1-2.2k	14
R206	1 kΩ	10%, 1/2 W	Comp	01121	EB	R1-1k	14
R207	2 kΩ	0.1%, 1/2 W	WW	54294	SP23D18	R67-2k	14
R208	2.2 kΩ	10%, 1/2 W	Comp	01121	EB	R1-2.2k	14
R209	56 kΩ	10%, 1/2 W	Comp	01121	EB	R1-56k	14
R210	10 kΩ	10%, 1/2 W	Comp	01121	EB	R1-10k	14
R211	10 kΩ	10%, 1/2 W	Comp	01121	EB	R1-10k	14
R212	47 kΩ	10%, 1/2 W	Comp	01121	EB	R1-47k	14
R213	56 kΩ	10%, 1/2 W	Comp	01121	EB	R1-56k	14
R214	47 kΩ	10%, 1/2 W	Comp	01121	EB	R1-47k	14
R215	1 kΩ	10%, 1/2 W	Comp	01121	EB	R1-1k	14
R216	1 kΩ	10%, 1/2 W	Comp	01121	EB	R1-1k	14
R217	Not Used						
R218	Not Used						
R219	Not Used						
R220	Not Used						
R221	Not Used						
R222	Not Used						
R223	1.8 kΩ	10%, 1/2 W	Comp	01121	EB	R1-1.8k	14
R224	12 Ω	10%, 1/2 W	Comp	01121	EB	R1-12	14
R225	6.04 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-6.04k	14
R226	1 kΩ	20%, 2 W	WW	71450	1NS115	RP50-1k	14
R227	2.21 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-2.21k	14
R228	20 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-20k	14
R229	20 kΩ	1%, 1/8 W	MtF	07716	CEA	R88-20k	14
R230	10 kΩ	10%, 1/2 W	Comp	01121	EB	R1-10k	14
R231	120 Ω	10%, 1/2 W	Comp	01121	EB	R1-120	14
R232	100 kΩ	10%, 1/2 W	Comp	01121	EB	R1-100k	14

TRANSISTORS

Circuit Desig.	Mfr. Code	Mfr. Desig.	Keithley Part No.	Fig. Ref.
Q201	04713	2N3905	TG-53	14
Q202	04713	MM4003	TG-59	14
Q203	04713	2N3905	TG-53	14
Q204 PNP, TO-92 Case	MOT	2N5087	TG-61	14
Q205	04713	2N3905	TG-49	14
Q206	02735	40346	TG-44	14
Q207	02735	40346	TG-44	14
Q208	04713	MM4003	TG-59	14
Q209	02734	40317	TG-43	14
Q210	02734	40319	TG-50	14

CODE—TO—NAME LIST

CODE TO NAME List of Suggested Manufacturers.
Reference: Federal Supply Code for Manufacturers, Cataloging Handbook H4-2.

00656	Aerovox Corp. 740 Belleville Ave. New Bedford, Mass. 02741
00686	Film Capacitors, Inc. 100 Eighth St. Passaic, N.J.
01121	Allen-Bradley Corp. 1201 South 2nd St. Milwaukee, Wisc. 53204
01295	Texas Instruments, Inc. Semiconductor-Components Div. Dallas, Texas 75231
01686	RCL Electronics, Inc. 195 McGregor St. Manchester, N.H. 03102
02101	Varo Inc. Electrokinetics Div. Santa Barbara, Calif. 93102
02660	Amphenol Corp. 2801 South 25th Ave. Broadview, Ill. 60153
02734	Radio Corp. of America Defense Electronic Products Camden, N.J.
02735	Radio Corp. of America Receiving Tube Div. Somerville, N.J.
02777	Hopkins Engineering Co. 12900 Foothill Blvd. San Fernando, Calif. 91342
02985	Tepro Electric Corp. 5 St. Paul St. Rochester, N.Y. 14604
03508	General Electric Co. Semiconductor Products Dept. Syracuse, N.Y. 13201
04009	Arrow-Hart & Hegeman Electric Co. 103 Hawthorne St. Hartford, Conn. 06106
04713	Motorola Semiconductor Prod. Inc. 5005 E. McDowell Rd. Phoenix, Ariz. 85008
05079	Tansistor Electronics, Inc. 1000 West Road Bennington, Vt. 05201
05397	Union Carbide Corp. Electronics Div. New York, N.Y. 10017
06751	Components, Inc. Arizona Div. Phoenix, Ariz. 85019
06980	Varian Assoc. EIMAC Div. 301 Industrial Way San Carlos, Calif. 94070
07137	Transistor Electronics Corp. Hwy. 169 - Co. Rd. 18 Minneapolis, Minn. 55424
07263	Fairchild Camera & Inst. Corp. 313 Frontage Road Mountain View, Calif.
07716	IRC, Inc. 2850 Mt. Pleasant Burlington, Iowa 52601
08811	GL Electronics Div. of GL Industries, Inc. Westville, N.J. 08093
09052	Gulton Industries, Inc. Alkaline Battery Div. Metuchen, N.J.
09823	Burgess Battery Co. Div. of Servel Inc. Freeport, Ill.
09922	Burndy Corp. Richards Ave. Norwalk, Conn. 06852
10582	CTS of Asheville Inc. Mills Gap Road Skyland, N.C.
11502	IRC Inc. Greenway Road Boone, N.C. 28607
11837	Electro Scientific Indus., Inc. 13645 NW Science Park Dr. Portland, Or. 97229
12040	National Semiconductor Corp. Commerce Drive Danbury, Conn. 06813
12065	Transitron Electronic Corp. 144 Addison St. East Boston, Mass.
12697	Clarostat Mfg. Co., Inc. Lower Washington St. Dover, N.H. 03820
12954	Dickson Electronics Corp. 302 S. Wells Fargo Ave. Scottsdale, Ariz.
13050	Potter Co. Highway 51 N. Wesson, Miss. 39191
13327	Solitron Devices, Inc. 256 Oak Tree Road Tappan, N.Y. 10983
13934	Midwec Corp. 602 Main Oshkosh, Nebr. 69154
14655	Cornell-Dubilier Electric Corp. 50 Paris Street Newark, N.J.
14659	Sprague Electric Co. P.O. Box 1509 Visalia, Calif. 93278
15238	ITT Semiconductors Div. of ITT Corp. Lawrence, Mass. 01841
15909	Daven Div. of T.A. Edison Ind. McGraw Edison Co. Livingston, N.J.
16170	Teledyne Systems Co. Communications Div. Los Angeles, Calif. 90066
17554	Components, Inc. Smith St. Biddeford, Ma. 04005
23020	General Reed Co. 174 Main St. Metuchen, N.J. 08840
24655	General Radio Co. 22 Baker Ave. West Concord, Mass. 01781
27682	Hathaway Instruments, Inc. 5800 E. Jewell Ave. Denver, Colorado 80222
28520	Heyman Mfg. Co. 147 N. Michigan Ave. Kenilworth, N.J.
29309	Richey Electronics Inc. 1307 Dickerson Rd. Nashville, Tenn. 37213
35529	Leeds and Northrup 4901 Stenton Ave. Philadelphia, Pa. 19144
37942	Mallory, P. R. and Co., Inc. 3029 E. Washington St. Indianapolis, Ind. 46206
44655	Ohmite Mfg. Co. 3601 Howard St. Skokie, Ill. 60076
53201	Sangamo Electric Co. 1301 North 11th Springfield, Ill. 62705
54294	Shallcross Mfg. Co. 24 Preston St. Selma, N.C.
56289	Sprague Electric Co. North Adams, Massachusetts
58474	Superior Electric Co., The 383 Middle St. Bristol, Conn. 06012
61637	Union Carbide Corp. 270 Park Ave. New York, N.Y. 10017

CODE TO NAME List (Continued).

63060	Victoreen Instrument Co. 5806 Hough Ave. Cleveland, Ohio 44103
70309	Allied Control Co., Inc. 2 East End Ave. New York, N.Y.
70903	Belden Mfg. Co. 415 So. Kilpatrick Chicago, Ill. 60644
71002	Birnbach Radio Co., Inc. 147 Hudson St. New York, N.Y.
71279	Cambridge Thermionic Corp. 430 Concord Avenue Cambridge, Mass.
71400	Bussmann Mfg. Div. of McGraw-Edison Co. St. Louis, Mo.
71450	CTS Corp. 1142 W. Beardsley Ave. Elkhart, Ind.
71468	ITT Cannon Electric, Inc. 3208 Humbolt St. Los Angeles, Calif. 90031
71590	Centralab Div. of Globe-Union, Inc. Milwaukee, Wisc. 53212
71785	Cinch Mfg. Co. and Howard B. Jones Div. Chicago, Ill. 60624
72619	Dialight Corp. 60 Stewart Ave. Brooklyn, N.Y. 11237
72653	G-C Electronics Co. 400 S. Wyman Rockford, Ill. 61101
72699	General Instrument Corp. Capacitor Division Newark, N.J. 07104
72982	Erie Technological Prods Inc. 644 W. 12th St. Erie, Pa. 16512
73138	Beckman Instruments, Inc. Helipot Division Fullerton, Calif. 92634
73445	Amperex Electronic Co., Div. of North American Philips Co., Inc. Hicksville, N.Y.
73690	Elco Resistor Co. 1158 Broadway New York, N.Y.
74276	Signalite Inc. 1933 Heck Ave. Neptune, N.J. 07753
74970	Johnson, E. F., Co. 297 Tenth Ave. S.W. Waseca, Minn. 56093
75042	IRC Inc. 401 North Broad St. Philadelphia, Pa. 19108
75915	Littlefuse, Inc. 800 E. Northwest Hwy. Des Plaines, Ill. 60016
76055	Mallory Controls, Div. of Mallory P. R. & Co., Inc. Frankfort, Ind.
76493	Miller, J. W. Co. 5915 S. Main St. Los Angeles, Calif. 90003
76545	Mueller Electric Co. 1583 E. 31st St. Cleveland, Ohio 44114
77764	Resistance Products Co. 914 S. 13th St. Harrisburgh, Pa. 17104
79727	Continental-Wirt Electronics Corp. Philadelphia, Pa.
80164	Keithley Instruments, Inc. 28775 Aurora Road Cleveland, Ohio 44139
80294	Bourns, Inc. 6135 Magnolia Ave. Riverside, Calif. 92506
81073	Grayhill, Inc. 561 Hillgrove Ave. La Grange, Ill. 60525
81483	International Rectifier Corp. 1523 East Grand Ave. El Segundo, Calif.
82389	Switchcraft, Inc. 5527 N. Elston Ave. Chicago, Ill. 60630
83125	General Instrument Corp. Capacitor Division Darlington, S.C. 29532
83330	Smith, Herman H., Inc. 812 Snediker Ave. Brooklyn, N.Y. 11207
83594	Burroughs Corp. Electronic Components Div. Plainfield, N.J. 07061
83701	Electronic Devices, Inc. Brooklyn, New York
84171	Arco Electronics, Inc. Community Drive Great Neck, N.Y. 11022
84411	TRW Capacitor Div. 112 W. First St. Ogallala, Nebr.
84970	Sarkes Tarzian, Inc. E. Hillside Dr. Bloomington, Ind.
86684	Radio Corp. of America Electronic Components & Devices Harrison, N.J.
87216	Philco Corp. Lansdale Div., Church Rd. Lansdale, Pa. 19446
90201	Mallory Capacitor 3029 East Washington Indianapolis, Ind. 46206
90303	Mallory Battery Co. Tarrytown, New York
91637	Dale Electronics, Inc. P.O. Box 609 Columbus, Nebr. 68601
91662	Elco Corp. Willow Grove, Pennsylvania
91737	Gremar Mfg. Co., Inc. 7 North Ave. Wakefield, Mass.
91802	Industrial Devices Inc. 982 River Rd. Edgewater, N.J. 07020
91929	Honeywell Inc. Micro Switch Div. Freeport, Ill. 61032
93332	Sylvania Electric Products, Inc. Semiconductor Products Div. Woburn, Mass.
93656	Electric Cord Co. 1275 Bloomfield Ave. Caldwell, N.J.
94144	Raytheon Co., Industrial Operation Components Div. Quincy, Mass.
94154	Tung-Sol Electric, Inc. Newark, New Jersey
94310	Tru-Ohm Products Memcor Components Div. Huntington, Ind. 46750
94696	Magnecraft Electric Co. 5579 North Lynch Chicago, Ill.
95348	Gordos Corp. 250 Glenwood Ave. Bloomfield, N.J. 07003
95712	Dage Electric Co., Inc. Hurricane Road Franklin, Ind.
97933	Raytheon Co. Components Div. Semiconductor Operation Mountain View, Calif.
99120	Plastic Capacitors, Inc. 2620 N. Clybourn Ave. Chicago, Ill.

SEE DWG. 24204E SCHEMATIC AMPLIFIER

REVISIONS			
LTR	ECO NO	APPR	DATE
B			
C	4300		3-25-74
D	5746		9-21-77

HIGHEST REFERENCE DESIGNATION					
Q210	C218	R232	D209	F201	P201
DS203	T201	J202	QA202	S202	

SCHEMATIC DESIGNATION NOT USED					
R222	R218	R219	R220	R221	R217

NOTES:
1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. ○ FRONT PANEL CONTROL
3. ⊘ INTERNAL SCREWDRIVER ADJ.
4. M MEGOHM
5. K 1000 OHM
6. pF PICOFARAD
7. ↑ CLOCKWISE ROTATION
8. ⊘ REAR PANEL CONTROL

+12V
-12V
+130V
-130V
+10V
-10V

R201 4.7K
R202 6.8K
R203 2K +V LIMIT LAMP ADJ.
R204 4.7K
C218 150pf
Q201
Q202
Q203
Q204
R205 2.2K
R206 1K
R207 2K -V LIMIT LAMP ADJ.
Q205
Q206
D201
D202
R208 2.2K
Q207
C201 470 pf
R209 56K
R214 47K
D203
R210 10K
Q208
R211 10K
D204
R212 47K
R213 56K
C202 .5

DS201
DS202
DS203
R232 100K

R224 12
D209
QA201
C213 100pF
R225 6.04K
R226 1K P.S. ADJ.
C211 100
R223 1.8K
C212 4.7
R228 20K
R227 2.21K
R229 20K
R230 10K
QA202
C215 10
R231 120
C214 .02
C216 10

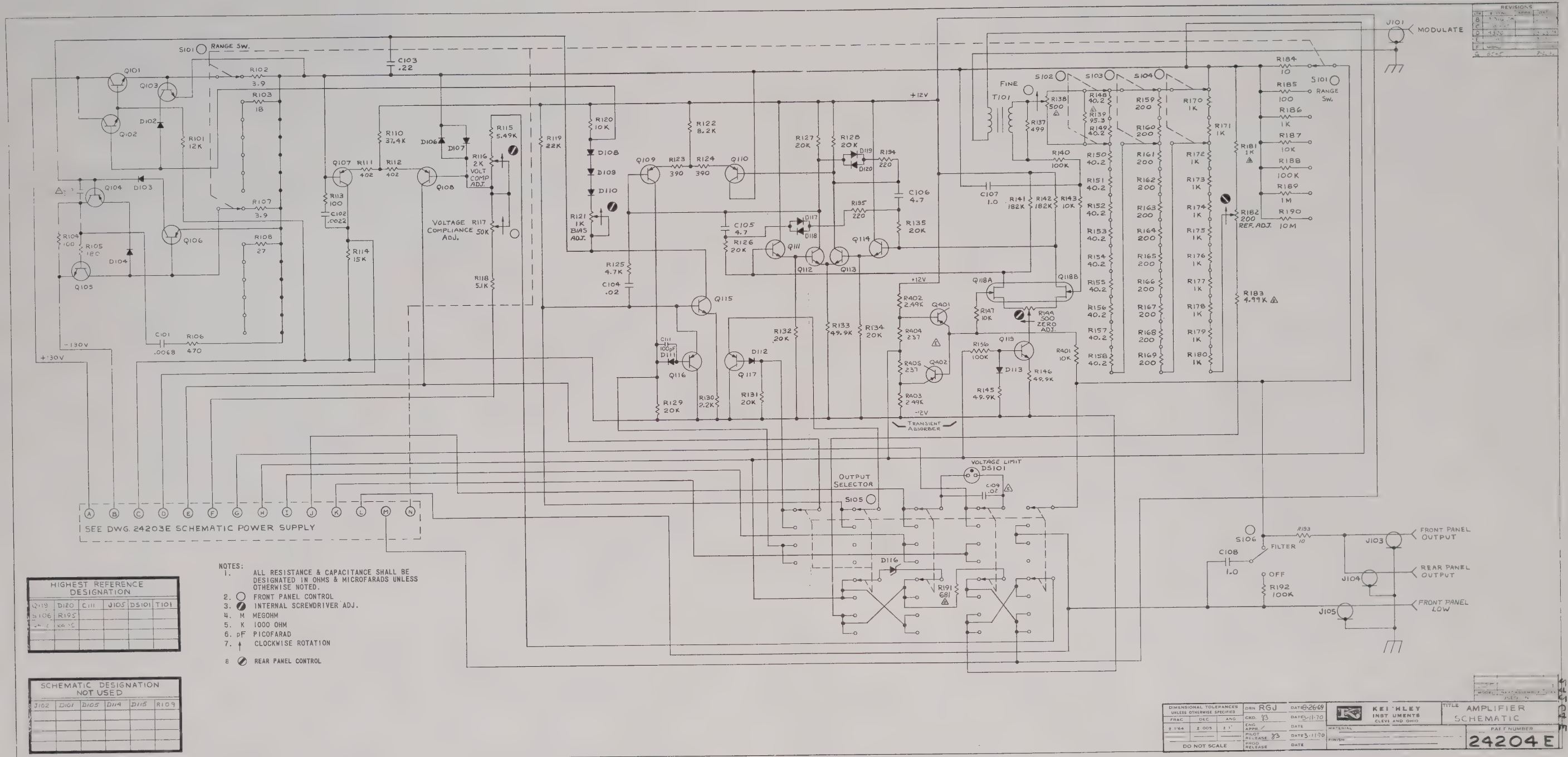
T201
LINE SW. S201 117V 50-60Hz
234V
117V
ON
S202
117V 50-60Hz
F201
P201
D207
D208
C203 .001
C204 .001
C205 140
C206 140
C207 100
C208 100
Q209
R215 1K
D205
C209 .001
D206
R216 1K
C210 .001
Q210

J201
CHASSIS GND
C217 .05
REMOVABLE LINK
REAR PANEL LOW J202

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED		
FRAC	DEC	ANG
± 1/64	± .005	± 1°
DO NOT SCALE		

DRN RGJ	DATE 9-8-69	KEITHLEY INSTRUMENTS CLEVELAND OHIO
CKD [illegible]	DATE 3-11-70	TITLE POWER SUPPLY SCHEMATIC
ENG APPR [illegible]	DATE 11-11-70	MATERIAL
PILOT RELEASE [illegible]	DATE 3-11-70	FINISH
PROD RELEASE	DATE	PART NUMBER 24203E

225		1
MODEL	NEXT ASSEMBLY	QUAN
USED ON		



HIGHEST REFERENCE DESIGNATION					
Q119	D120	C111	J105	DS101	T101
S106	R195				

SCHEMATIC DESIGNATION NOT USED					
J102	D101	D105	D114	D115	R109

NOTES:
1. ALL RESISTANCE & CAPACITANCE SHALL BE DESIGNATED IN OHMS & MICROFARADS UNLESS OTHERWISE NOTED.
2. ○ FRONT PANEL CONTROL
3. ⊘ INTERNAL SCREWDRIVER ADJ.
4. M MEGOHM
5. K 1000 OHM
6. pF PICOFARAD
7. ↑ CLOCKWISE ROTATION
8. ⊘ REAR PANEL CONTROL

REVISIONS			
LTR	DESCRIPTION	APPD	DATE
A			
B			
C			
D			
E			
F			
G			

DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED					
FRAC	DEC	ANG			
± 1/64	± .005	± 1°			
DO NOT SCALE					

DRN RGJ	DATE 8-2669	KEITHLEY INSTRUMENTS CLEVELAND OHIO
CKD. [illegible]	DATE 3-11-70	TITLE AMPLIFIER SCHEMATIC
ENG. APPR.	DATE	MATERIAL
PILOT RELEASE [illegible]	DATE 3-1170	FINISH
PROD. RELEASE	DATE	PART NUMBER 24204E

KEITHLEY

SERVICE FORM

Model No. _____ **Serial No.** _____ **P.O. No.** _____ **Date** _____

Name _____ **Phone** _____

Company _____

Address _____

City _____ **State** _____ **Zip** _____

List all control settings and describe problem. _____

_____

_____

_____ (Attach additional sheets as necessary.)

Show a block diagram of your measurement system including all instruments connected (whether power is turned on or not). Also describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.) _____

What power line voltage is used? _____ Variation? _____

Frequency? _____ Ambient Temperature? _____ °F.

Variation? _____ °F. Rel. Humidity? _____ Other? _____

Any additional information. (If special modifications have been made by the user, please describe below.)

_____

_____

*Be sure to include your name and phone number on this service form.

MP MASTER

MA25844

KEITHLEY

Keithley Instruments, Inc./28775 Aurora Road/Cleveland, Ohio 44139/U.S.A./(216) 248-0400/Telex: 98-5469
WEST GERMANY: Keithley Instruments GmbH/Heiglhofstrasse 5/D-8000 München 70/(089) 714-40-65/Telex: 521 21 60
GREAT BRITAIN: Keithley Instruments, Ltd./1, Boulton Road/Reading, Berkshire RG2 ONL/(0734) 86 12 87/Telex: 847047
FRANCE: Keithley Instruments SARL/2 Bis, Rue Léon Blum/B.P. 60/91121 Palaiseau Cedex/(6) 011.51.55/Telex: 600933F
NETHERLANDS: Keithley Instruments BV/Arkelsedijk 4/NL-4206 AC Gorinchem/(01830) 25577/Telex: 24 684
SWITZERLAND: Keithley Instruments SA/Kriesbachstr. 4/CH-8600 Dübendorf/01 821 94 44/Telex: 57 536
AUSTRIA: Keithley Instruments Ges.m.b.H./Döblinger Hauptstr. 32/A-1190 Wien/0222 314 289/Telex: 13 45 00